Study Protocol and Statistical Analysis Plan

Official Title:

The Effect of Vibration and Cold on Pain and Anxiety Associated with Chest Tube Removal Following Coronary Artery Bypass Graft Surgery: A Randomized Controlled Study

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1. Scientific Background and Rationale

Chest tube removal following coronary artery bypass graft (CABG) surgery is recognized as one of the most painful routine postoperative procedures. Despite routine pharmacological analgesia, patients frequently experience moderate-to-severe pain and significant anxiety, which may lead to sympathetic activation, delayed mobilization, and respiratory complications.

Vibration therapy activates cutaneous mechanoreceptors and modulates nociceptive transmission according to gate control theory, thereby reducing perceived pain intensity. Cold application produces local vasoconstriction, decreases nerve conduction velocity, and elevates the pain threshold. Although cold therapy has been studied in chest tube removal, vibration has not been evaluated as an independent intervention in this clinical context. Additionally, the potential synergistic effect of vibration combined with cold therapy remains unclear.

This randomized controlled trial aims to provide mechanistic and clinical evidence regarding the independent and combined analgesic and anxiolytic effects of vibration and vibration-integrated cold therapy during chest tube removal after CABG surgery.

2. Objectives and Hypotheses

Objectives

- To evaluate the effect of vibration and vibration-integrated cold therapy on pain intensity during chest tube removal.
- To evaluate the effect on anxiety level

Hypotheses

$H1_1$: The level of pain associated with chest tube removal in patients who received vibration and cold therapy after coronary artery bypass graft surgery was lower than in those who did not receive it.

$H1_2$: The level of pain associated with chest tube removal in patients who received vibration therapy after coronary artery bypass graft surgery was lower than in those who did not receive it.

$H1_3$: The level of pain associated with chest tube removal in patients who received vibration and cold therapy after coronary artery bypass graft surgery was lower than in those who did not receive it.

$H1_4$: The level of anxiety associated with chest tube removal in patients who received vibration and cold therapy after coronary artery bypass graft surgery was lower than in those who did not receive it.

$H1_5$: The level of anxiety associated with chest tube removal in patients who received vibration therapy after coronary artery bypass graft surgery was lower than in those who did not receive it.

$H1_6$: The level of anxiety associated with chest tube removal in patients who received vibration and cold therapy after coronary artery bypass graft surgery was lower than in those who did not receive it.

3. Study Design

This study is a partial single-blind, randomized controlled trial conducted to evaluate the effects of vibration and vibration combined with cold therapy on pain and anxiety associated with chest tube removal following coronary artery bypass graft surgery.

Three-arm parallel, partial single-blind randomized controlled trial. Allocation ratio: 1:1:1

Groups:

- Vibration group
- Vibration + Cold group
- Control group

Sample size: 93 participants (31 per group) determined using G*Power (alpha=0.05, power=0.80, effect size d=0.329).

4. Randomization and Blinding

Randomization: Randomization sequence generated by independent statistician using computer-based random number generator. Allocation concealment: sealed opaque envelopes. Assignment performed by independent nurse not involved in study

implementation.

Blinding: Due to nature of intervention, participants and implementer not blinded. Outcome recording standardized and statistical analysis conducted blinded to group allocation

5. Study Setting and Period

The study was conducted in a Thoracic and Cardiovascular Surgery Training and Research Hospital between September 2024 and June 2025.

6. Participants

Inclusion and exclusion criteria were predefined according to clinical and ethical standards.

Inclusion Criteria:

Patients were included in the study if they:

- had a chest tube placed for the first time,
- had both mediastinal and thoracic chest tubes,
- had an American Society of Anesthesiologists (ASA) classification ≤ III,
- were between 40 and 65 years of age,
- were conscious, oriented, and cooperative.

Exclusion Criteria:

Patients were excluded from the study if they:

- had a chest tube in place for longer than 72 hours,
- had impaired skin integrity at or around the chest tube insertion or application site (scar, laceration, erythema, inflammation, burn, or infection),
- had a history of previous coronary artery bypass graft surgery,
- had diabetes mellitus,
- had a history of thoracotomy,

- were under the effects of anesthesia or analgesia,
- developed intraoperative or postoperative complications,
- were intubated,
- had cold urticaria,
- were unable to speak Turkish or had hearing or visual impairment,
- had a diagnosed psychiatric or mental disorder,
- had a body mass index ≥ 30,
- participated in another clinical trial during the same period.

7. Interventions

PPatients participating in the study were randomly divided into three groups: vibration group, vibration + cold group, and control group. All procedures were performed by a trained investigator according to standardized and predefined protocols. The procedures were carried out in the same way for all participants.

Vibration + Cold Group: Patients in this group underwent a combined non-pharmacological intervention before chest tube removal. Cold gel packs, maintained at -20°C, were placed around the chest tube insertion sites, wrapped in sterile protective drapes to reduce the risk of infection. Cold therapy was started 20 minutes before chest tube removal. Skin temperature was monitored using a non-contact digital infrared thermometer and kept above 12°C. Gel packs were changed every 5 minutes to maintain the target temperature range. At the 10th minute of cold therapy, the vibration device (Vibracool®, Pain Care Labs)* was placed between the two cold gel packs, in the 9th–10th intercostal space. The device was used at the manufacturer's default therapeutic vibration setting. Vibration was applied until the chest tube removal procedure was completed. Pain, anxiety, and physiological measurements were recorded before, during, and after the procedure, according to predetermined measurement times.

Vibration Group: Patients in the vibration group received only vibration therapy. The vibration device, wrapped in a sterile protective sheath, was placed proximal to the chest tube insertion site in the 9th–10th intercostal space. Vibration therapy was started 10 minutes before chest tube removal and continued throughout the tube removal procedure. The therapy was terminated immediately after chest tube removal. Skin temperature was monitored, and all outcome measurements were performed at the

same time points as the other groups.

Control Group: Patients in the control group did not receive any additional non-pharmacological interventions other than standard postoperative care. Chest tube removal was performed in accordance with routine clinical practice. Pain, anxiety, and physiological measurements were recorded at the same time points as the intervention groups.

All chest tube removal procedures were performed by the same clinical team using a standard technique. During the intervention period, no analgesic or anxiolytic interventions were administered.

> ***Vibracool®:*** *VibraCool® Pro is a reusable therapeutic vibration device used for temporary pain relief via localized mechanical stimulation with or without cold therapy. The device provides fixed vibration output and was used according to manufacturer instructions without adjustment of device parameters. Cold packs were applied in conjunction with the vibration unit and skin condition was monitored during use.*

8. Safety Monitoring

- Skin checked every 5 minutes
- Stop if skin temperature <12°C or discomfort
- All adverse events recorded. Adverse events were defined as skin injury, excessive pain, intolerance to cold, or any event requiring termination of the intervention. There were no adverse effects.
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9. Outcomes

- **Primary outcome:** Pain intensity measured using the Visual Analog Scale (VAS). The primary endpoint was pain intensity measured by a 10-cm Visual Analog Scale during chest tube removal (T2 time point). Lower scores indicated lower pain intensity and a better clinical outcome.
- **Secondary outcome:** Anxiety level measured using the State Anxiety Inventory (STAI-I), vital signs.
- **Measurement Timepoints**

Time	Description
T0	20 min before removal
T1	Immediately before

T2	During removal
T3	5 min after
T4	10 min after
T5	15 min after

10. Statistical Analysis Plan

10.1. Software and General Principles

All statistical analyses were performed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). All tests were two-tailed and interpreted at a significance level of $\alpha = 0.05$ unless otherwise specified. Estimates were reported with 95% confidence intervals (CI).

10.2. Data Distribution and Reliability

Normality of continuous variables was evaluated using:

- Descriptive methods (skewness–kurtosis and SD/mean ratio)
- Graphical methods (Q–Q plots and histograms)
- Kolmogorov–Smirnov test

Internal consistency of the State Anxiety Inventory (STAI-I) was assessed using Cronbach's alpha ($\alpha = 0.777$).

10.3. Baseline and Between-Group Comparisons

- Continuous variables: One-way ANOVA
- Multiple group comparisons: Tukey post-hoc test (when ANOVA significant)
- Two-group comparisons: Independent samples t-test
- Categorical variables: Pearson chi-square or Fisher's exact chi-square test

10.4. Repeated Measurements

- Repeated measurements were analyzed using a repeated measures ANOVA model including time and group factors. Time (T0–T5) was treated as the within-subject factor and study group (vibration, vibration + cold, control) as the between-subject factor. The

group × time interaction term was examined to determine whether changes in outcomes over time differed between groups. When the overall model was significant, temporal changes were evaluated using Bonferroni correction and between-group differences were explored using post-hoc comparisons. Between-group differences were additionally evaluated using ANCOVA while controlling for baseline values. Baseline score of the respective outcome variable was entered as a covariate.

10.5. Effect Size

Effect sizes were calculated using eta squared (η^2).

10.6. Statistical Significance

The level of statistical significance was accepted as $p < 0.05$.

10.7. Missing Data

No imputation was performed and analyses were conducted using available case data.

11. Ethics

The study was approved by the Clinical Research Ethics Committee prior to initiation. The research was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants before enrollment in the study. Following the pilot phase, no protocol amendments affecting study procedures or outcomes were made after trial initiation.