Comparative Study of the Efficacy of Intraoperative Intercostal Cryoanalgesia and Thoracic Epidural Block in the Postoperative Period of Minimally Invasive Pectus Excavatum Repair (MIRPE): a Prospective, Randomized Clinical Trial

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SUMMARY

ABSTRACT

Objective: Minimally invasive repair of pectus excavatum (MIRPE) is associated with significant postoperative pain, prolonged hospitalization, and high opioid requirements. The objective of this study is to compare the analgesic efficacy of intraoperative intercostal nerve cryoablation with epidural analgesia by measuring hospital length of stay.

Design: Randomized clinical trial evaluating 40 consecutive participants undergoing MIRPE using two metallic bars placed in parallel or crossed configuration. Participants will be randomized in a 1:1 ratio to receive intraoperative intercostal cryoanalgesia or thoracic epidural block.

Setting: Single institution, Heart Institute (InCor), University of São Paulo (USP).

Participants: Forty consecutive participants scheduled for the Nuss procedure will be recruited. Exclusion criteria include age under 13 years, chest wall deformities other than pectus excavatum, previous repair or other thoracic surgery, and chronic use of pain medications.

Primary outcomes and measures: The primary outcome was postoperative length of stay (LOS). Secondary outcomes include total operative time, total/daily opioid requirements, pain scores in hospitalized and outpatient participants, postoperative satisfaction at 6 months, total hospitalization cost, and postoperative complications within 30 days. Primary outcome data will be analyzed using the Mann–Whitney U test for nonparametric continuous variables. Other continuous variables will be analyzed using a two-tailed t-test, while categorical data will be compared using the chi-square test, with alpha = 0.05 for statistical significance.

INTRODUCTION

Pectus excavatum (PE), characterized by an anterior depression of the chest wall, is the most common congenital chest wall deformity, with a prevalence of approximately 6.3 to 12 per 1,000 individuals worldwide.

First introduced in the 1990s, the Nuss procedure, also known as minimally invasive repair of pectus excavatum (MIRPE), is currently the most commonly performed surgical procedure for correction.

Although the benefits of this approach include smaller incisions, shorter operative time, and reduced blood loss compared with the open Ravitch repair, the immediate remodeling of the chest wall is associated with significant postoperative pain.

Currently, the two most common pain control strategies after MIRPE are thoracic epidural infusion and intravenous patient-controlled analgesia (PCA).

In addition, a variety of multimodal regimens using indwelling chest wall catheters and local or regional nerve blocks have recently been proposed to reduce perioperative pain and opioid use.

However, all these regimens provide relatively short-term control, whereas pain following MIRPE typically persists for 2 to 4 weeks.

To achieve long-lasting pain control at the time of surgery, cryoanalgesia—defined as the use of cold temperature to interrupt nerve function—has been employed for peripheral nerve blockade.

The concept of using ice or cold temperatures to anesthetize pain dates back to Hippocrates (460–377 BC), who described the use of ice and snow compresses to relieve surgical pain.

The modern version of this concept utilizes a commercially available cryoprobe that releases carbon dioxide or nitrous oxide under high pressure, rapidly cooling tissues to −50 to −70 °C. This temperature induces Wallerian degeneration of axons, temporarily preventing pain transmission. The external fibrous neural structures remain intact, facilitating axonal regeneration within approximately 4 to 6 weeks.

Table 1 lists publications from the last six years that evaluated postoperative pain in patients undergoing MIRPE with cryoanalgesia and the methodologies employed.

Tabela 1 – Estudos entre 2019 e 2024 que avaliaram a resposta analgésica no pós-operatório de MIRPE

Study	Place	Study design	Patients	Primary outcome	Secondary outcomes
Jaroszewski et al (2024) [28]	Mayo Clinic Arizona, USA	Retrospective	729 adults	Length of Stay, opioid comsumption	Postoperative complications, pain scales
Ganescu et al (2022) [29]	The Montreal Children's Hospital, Canada	Retrospective	57 teenagers and adults	Opioid comsumption	Pain scales
Downing et al (2023) [30]	The Hospital for Sick Children, Canada	Retrospective	53 teenagers	Lenght of stay	Opioid comsumption, pain scales
Arshad et al (2023) [31]	Multicentric, USA	Retrospective	898 teenagers	Length of stay and opioid comsumption	Postoperative complications and readmissions
Toselli et al (2024) [32]	Buenos Aires, Argentina	Retrospective	176 teenagers and adults	Length of Stay, opioid comsumption	Pain scales
Parrado et al (2019) [33]	Phoenix Children's Hospital, USA.	Retrospective	101 teenagers	Late pneumotórax	Length of Stay, pain scales, opioid comsumption, bar dislodgement

Song et al (2022) [34]	Sanggye Paik Hospital, South Korea	Retrospective	64 teenagers	Opioid comsumption and length of stay	Pain scales
Graves et al (2019) [35]	UCSF-Benioff Children's Hospital, USA	Prospective, randomized	20 patients (1:1)	Length of stay	Operative time, opioid comsumption, pain scales, postoperative complications

The only randomized trial in the literature concluded that intercostal nerve cryoablation during MIRPE reduces length of stay and opioid requirements compared with thoracic epidural analgesia.

However, that study did not differentiate whether one or multiple metallic bars were used during MIRPE. One of the most feared complications of MIRPE is postoperative bar rotation, and the search for solutions to this problem is longstanding.

The placement of more than one bar is one strategy that may minimize this complication. Additionally, two metallic bars may distribute the pressure exerted on the sternum, which could have implications for postoperative pain. Despite this, traditional bars were designed to be used individually, and when more than one bar is used, technical adaptations such as steel sutures are required for fixation.

Recently, a new material for performing MIRPE has become available in our setting.

One of the characteristics of this material is a dedicated system that allows fixation of more than one metallic bar, providing greater adaptability and enhanced stability of the system on the patient’s chest wall. Furthermore, the use of more than one metallic bar has become a trend in MIRPE, not only for safety reasons but also for improved corrective outcomes.

Thus, the objective of the present study is to compare intraoperative intercostal cryoanalgesia with thoracic epidural block in the postoperative period of MIRPE performed with more than one metallic bar.

OBJECTIVES

Primary objective

Minimally invasive repair of pectus excavatum (MIRPE) is associated with significant postoperative pain, prolonged hospitalization, and high opioid requirements. The objective of this study is to compare the analgesic efficacy of intraoperative intercostal nerve cryoablation with epidural analgesia by measuring hospital length of stay (in days).

Secondary objectives

To compare the analgesic response between perioperative intercostal cryoablation and epidural analgesia using visual analog scale (VAS) and numeric rating scale (NRS) pain scores.

To compare intravenous opioid consumption in the postoperative period of MIRPE between the intercostal cryoablation group and the thoracic epidural block group, expressed as oral morphine equivalents.

To compare the rate of perioperative complications within 30 days in patients undergoing MIRPE using the Clavien–Dindo classification.

To compare the frequency of emergency department visits or hospital readmissions between the intercostal cryoablation and thoracic epidural block groups within 30 days after hospital discharge.

To observe the incidence of chronic neuropathic pain and paresthesia up to 1 year postoperatively in the intercostal cryoablation group.

To compare patient-reported experience measures (PREMs) between the intercostal cryoablation and thoracic epidural block groups using postoperative satisfaction at 6 months assessed by the Single Step Questionnaire (SSQ).

To compare total hospitalization costs (in Brazilian Reais) and costs per hospital sector (ward, operating room, and intensive care unit) between the two groups.

HYPOTHESIS

Intraoperative intercostal cryoablation used as an analgesic method in minimally invasive repair of pectus excavatum (MIRPE) is more effective in reducing postoperative pain than thoracic epidural block, thereby reducing postoperative hospital length of stay.

METHODOLOGY

Study Design

Prospective randomized clinical trial of participants undergoing MIRPE at a single academic institution. Participants will be randomized in a 1:1 ratio to receive cryoanalgesia or thoracic epidural analgesia for perioperative pain control. All procedures were reviewed and approved by the institutional review board.

Participant Selection

Participants will be consecutively recruited from among those who sought care at the Chest Wall Outpatient Clinic of InCor and who had already been scheduled to undergo MIRPE through routine hospital care. Only healthy participants with pectus excavatum deformity will be included.

Inclusion Criteria

1) Diagnosis of pectus excavatum;

2) Signed informed consent form for participation in the study.

Exclusion Criteria

1) Age < 13 years at the time of the procedure;

2) Chronic use of analgesics in the preoperative period;

3) Pectus carinatum, Poland syndrome, or other chest wall anomalies;

4) Previous repair of pectus excavatum using any technique;

5) Previous thoracic surgery;

6) Congenital heart disease;

7) Hemorrhagic diathesis;

8) Major anesthetic risk factors or history of previous anesthetic complications;

9) Pregnancy.

Randomization

On the day of surgery, in the preoperative area, shortly before the surgical procedure, a list generated by a computerized random sequence generator (http://www.random.org/) will be consulted in a 1:1 ratio between the cryoanalgesia and thoracic epidural groups. The list will be handled by third parties not involved in the study.

MIRPE procedure and analgesia

All participants will undergo the MIRPE procedure, performed by two attending surgeons experienced in the technique. Specific aspects of the procedure (i.e., size and positioning of bars in crossed or parallel configuration, size of transverse stabilizing bars) will be left to the surgeon's discretion based on individual participant factors. However, the same surgical technique will be applied throughout the protocol for all participants. The technique used has been previously described [38,39] and is summarized below.

After measuring the lengths of the metallic bars to be used for surgical correction, two lateral incisions of approximately three centimeters are made on each side of the chest. The incisions begin approximately one centimeter below the point where the bar will be positioned and extend two centimeters medially. Blunt dissection is performed to create a subcutaneous tunnel to the point of entry into the thoracic cavity (hinge point), where, after ventilatory pause, the thoracic cavity is opened and the optic device is introduced for cavity exploration.

Next, two screws are fixed into the anterior sternal table to allow performance of the Crane maneuver, which consists of elevating the sternum using a Thompson retractor. The sternum is kept elevated not only for dissection of the retrosternal tunnels but also throughout the entire surgery.

Under thoracoscopic visualization, the retrosternal tunnels are dissected from left to right as previously described, and 28 French thoracic drains are passed through the tunnels to serve as guides for insertion of the metallic bars.

The metallic bars are shaped for the participant, attached to the end of the drain, and passed through the retrosternal tunnels in a concave position. Subsequently, one bar at a time is rotated to its convex position, the sternal elevation is released, and the effect obtained by the presence of the bar elevating the sternum is evaluated. The same sequence is then performed with the second bar, and the process is repeated until the result is considered satisfactory.

Subsequently, the bars are fixed with bridges to prevent displacement. The thoracic cavities are drained, air is evacuated from the pleural cavities, and the surgical incisions are closed in layers.

Participants Randomized to Epidural Analgesia

Participants will be intubated with a single-lumen endotracheal tube. A thoracic epidural catheter will be placed by the pediatric anesthesia team immediately before the MIRPE procedure. Catheters will be placed using sterile technique at approximately interspaces T5–6 or T6–7; specific details of the procedure will be left to the discretion of the

attending anesthesiologist. After placement, the epidural infusion will be initiated with 0.1% ropivacaine and fentanyl 2 µg/cc. No bolus doses will be administered. Participants in the cryoanalgesia arm will not receive preoperative thoracic epidural placement, and participants in the epidural arm will not receive intraoperative cryoanalgesia.

Participants Randomized to Intercostal Nerve Cryoablation (IC)

Intercostal cryoablation is performed prior to placement of the retrosternal metallic bars. Participants randomized to cryoanalgesia will be intubated with a double-lumen endotracheal tube to allow better lung isolation and exposure of the posterolateral trajectory of the intercostal nerves.

Next, a 5-mm trocar is inserted into the right thorax inferior to the incision made for metallic bar placement. Using the incision created for bar placement, the cryoablation probe is inserted above the rib deep to the incision. Under thoracoscopic guidance, the probe is positioned on the inferior portion of the neurovascular bundle posterolaterally and away from the spine without contacting the lungs. Intercostal nerves between T3 and T7, corresponding to the incision level and two interspaces above and below, are subjected to cryoablation for two minutes each at −60 °C. Each nerve receives one cryoablation cycle. After freezing, the probe is warmed to room temperature to allow detachment from the chest wall.

Subsequently, the intercostal nerve bundle in the contralateral thoracic cavity is subjected to cryoablation using the same technique [40].

Postoperative care

Postoperative care and the analgesic protocol will be identical for all participants, except for continuous epidural infusion (without bolus or patient-controlled epidural analgesia). All participants will be admitted to the thoracic surgery ward.

The study team will quantify daily the total dose of analgesics and adjuvants administered during hospitalization, via parenteral and enteral routes (Table 2), in both treatment groups. Local field block will be performed intraoperatively at all incision sites.

All participants, in the absence of hypersensitivity restrictions, will receive 48 hours of dipyrone (metamizole) and nonsteroidal anti-inflammatory drugs (ketorolac trometamol, ketoprofen, or similar agents available at the institution) intravenously. Once participants tolerate oral intake, they will be converted to oral oxycodone, acetaminophen or dipyrone, and nonsteroidal anti-inflammatory drugs (ibuprofen, ketorolac trometamol, or ketoprofen).

Table 2 – Administration of Analgesics and Anti-inflammatory Drugs in the Postoperative Period

Postoperative day (POD)	0	1	2	3	4	5	6 (...)
Epidural, 0.1% ropivacaine, fentanyl 2 µg/cc at 6 cc/h							
Ketoprofen 100 mg IV							
Ketorolac trometamol 30 mg							
Hydromorphone PCA, 0.1 mg							
Oxycodone 5 mg							
Oxycodone 10 mg							
Acetaminophen 650 mg							
Ibuprofen 10 mg/kg/dose							
Ondansetron 4 mg IV							
Gabapentin 300 mg							
Baclofen 10 mg							

According to institutional protocol, all epidurals will be weaned off at the discretion of the pain management team in consultation with the surgical team. The use of narcotics will be recorded and tracked through the hospital's electronic medical record.

Pain Scores

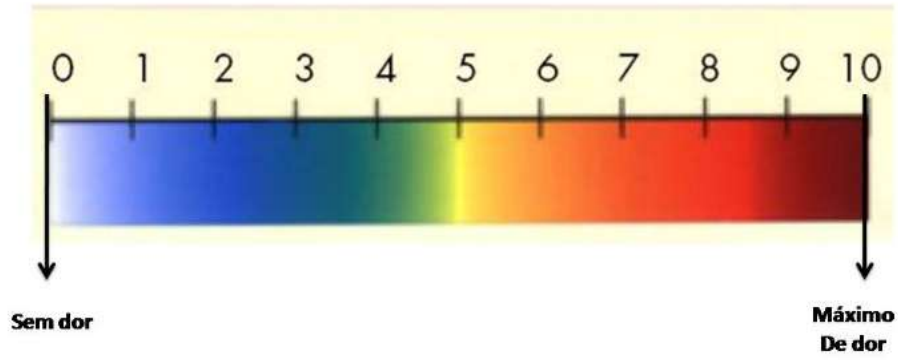
In addition to standard postoperative nursing assessments, participants' pain (including specific neuropathic pain described as "burning," "electric," or "tingling" sensations) will be assessed by a study questionnaire using visual analog and numeric pain scales (0 to 10) in seated and supine positions, and according to reported pain location in quadrants (anterior, posterior, superior, inferior, lateral, medial).

On the numeric scale, the value 0 represents no pain, while the value 10 identifies the most intense pain experienced by the patient [41].

Patients frequently experience difficulty using numeric values alone due to the absence of clear definitions of what each number represents, given that pain is subjective and such scales attempt to transform it into an objective representation [42].

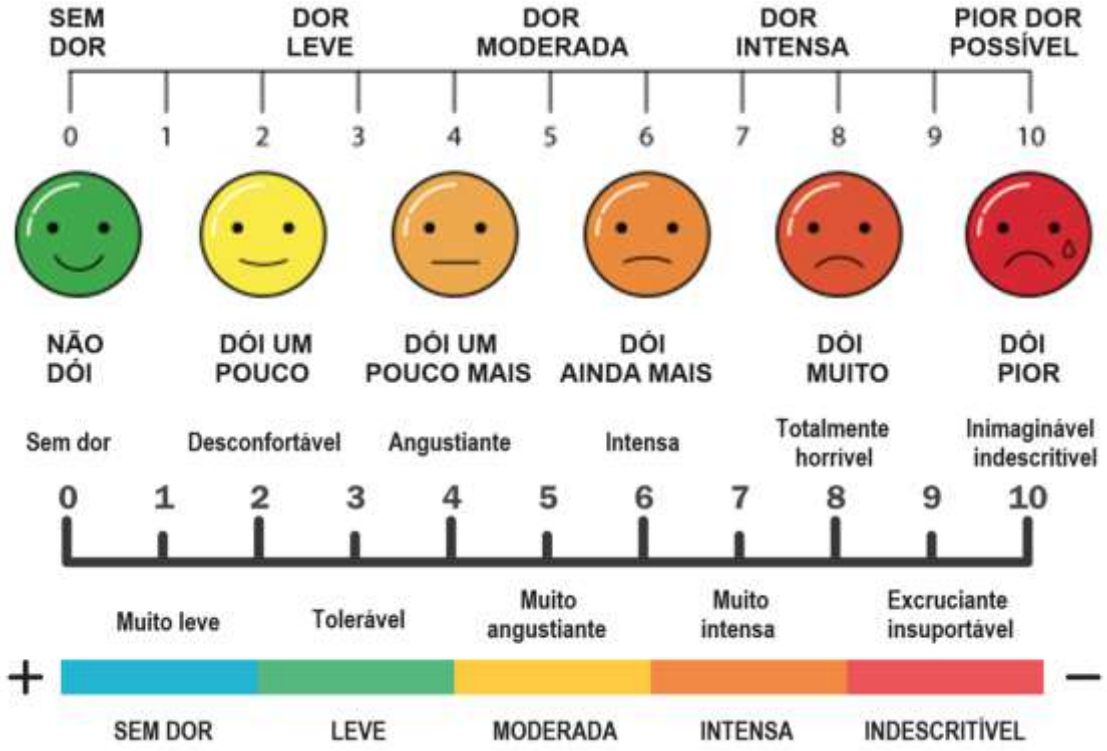
The visual pain score is displayed with digits ranging from 0 to 10 and is determined using a standard, such as a spectrum of cold and warm colors or facial expressions [41,43] (Figures 1 and 2).

Figure 1 – Visual analog pain scale based on a color spectrum (warm and cool colors).



Reproduced from Fortunato JGS (2013), Revista HUPE, 12(3), 110-118 [43].

Figura 2 – Conversion between numeric and analog visual pain scales.



Adapted from International Living Donor Liver Transplant Registry.

Hospital discharge will be determined by the surgical team based on adequate pain control with oral medications, ability to ambulate independently, and tolerance of oral diet.

Pain Biomarkers

The National Institutes of Health (NIH) led the creation of a consortium to validate existing biomarkers (previously identified in small studies) and to develop and discover

new biomarkers and biosignatures related to the evolution of postoperative pain into chronic pain.

Thus, the Food and Drug Administration's (FDA) Biomarkers, Endpoints, and Other Tools (BEST) framework defined multiple types of biomarkers, including susceptibility/risk, prognostic, predictive, and monitoring biomarkers. These biomarkers provide a broader perspective and include psychosocial measures, which serve as indirect indicators of more complex biological processes.

Among the primary patient-reported biomarkers are overall and local pain intensity, diffuse pain, movement-evoked pain, and pain trajectory. Among laboratory and imaging markers, primary biomarkers include C-reactive protein and other inflammatory substances such as interleukins 6 and 12, as well as sensory testing and neuroimaging.

The literature contains only one publication, available as a preprint, that evaluated biomarkers and their association with acute and chronic postoperative pain in MIRPE. This prospective observational study identified an association between levels of pro-inflammatory and anti-inflammatory cytokines and the development of acute and chronic pain, respectively.

Patient-Reported Outcome Measures (PROMs) and Patient-Reported Experience Measures (PREMs)

Patient-reported experience measures (PREMs) are tools that allow assessment of what occurred during a treatment and how it occurred from the patient's perspective, whereas patient-reported outcome measures (PROMs) allow measurement of the patient's health status, including patient-related factors and pain-related condition factors, as well as external factors that may be associated with pain.

The PROMs listed in the NIH Acute to Chronic Pain Signatures (A2CPS) initiative have the most robust evidence encompassing pain and other symptoms, psychosocial factors, and function. These PROMs are subdivided into the following domains: pain, function, disability, mood/affect, sleep, cognitive function, resilience, trauma, and social support. Table 3, adapted from Sluka et al. (2023), lists the primary and secondary biomarkers assessable within the PROMs domain and Pain category.

Table 3 – Primary and secondary biomarkers in the assessment of chronic and acute pain – PROMs domain, Pain category – adapted from Sluka et al. (2023).

Primary biomarkers	Secondary biomarkers
- Overall pain intensity	- Pain duration
- Local pain intensity	- Pain impact/quality of life
- Widespread body pain	- Pain interference
- Movement-evoked pain	
- Pain trajectory	
Primary biomarkers	

Among the PREMs, the Single-Step Questionnaire (SSQ) is a validated tool used to assess general and health-related satisfaction, self-image, and postoperative pain, as well as improvement in quality of life related to physical and psychosocial domains, in adolescent and young adult patients undergoing minimally invasive repair of pectus excavatum. It is administered at a single time point starting from the fifth postoperative month.

For calculation of the total score: the preoperative self-esteem score is subtracted from the postoperative self-esteem score. The difference between the two values is used as a single contributor to the total score.

Hospitalization Costs

Two retrospective studies evaluated hospitalization costs for admissions related to MIRPE associated with cryoanalgesia. Based on univariate and multivariate analyses, a trend toward cost savings associated with the use of cryoanalgesia during MIRPE was observed, which is likely related to improved analgesic response and reduced total length of hospital stay when compared with patients undergoing conventional analgesia (with or without epidural block) without intercostal cryoablation.

Follow-up

After hospital discharge, participants will be sent home with acetaminophen or dipyrone, a nonsteroidal anti-inflammatory drug, and oxycodone, and will be instructed to maintain a medication log. Participants will be scheduled for follow-up visits at 2 weeks, 1 month, 3 months, 6 months, and 12 months from the date of surgery. Each visit will consist of an interval history and a focused physical examination, including specific assessment of incision sites, chest wall sensation, and the epidural catheter insertion site.

At each visit, participants will also complete a questionnaire including questions regarding the type and severity of pain, satisfaction with the pain control regimen, level of physical activity, and side effects or adverse events (Table 4).

Table 4 – Adverse effects related to analgesia

Adverse event	POD 0	POD 1	POD 2	POD 3	POD 4	POD 5
- Nausea, vomiting						
- Pruritus						
- Urinary retention						
- Respiratory depression						
- Naloxone administration						
- SpO_2 < 90%						
- Respiratory rate < 8 breaths per minute						

Endpoints, Power Calculation, and Data Analysis

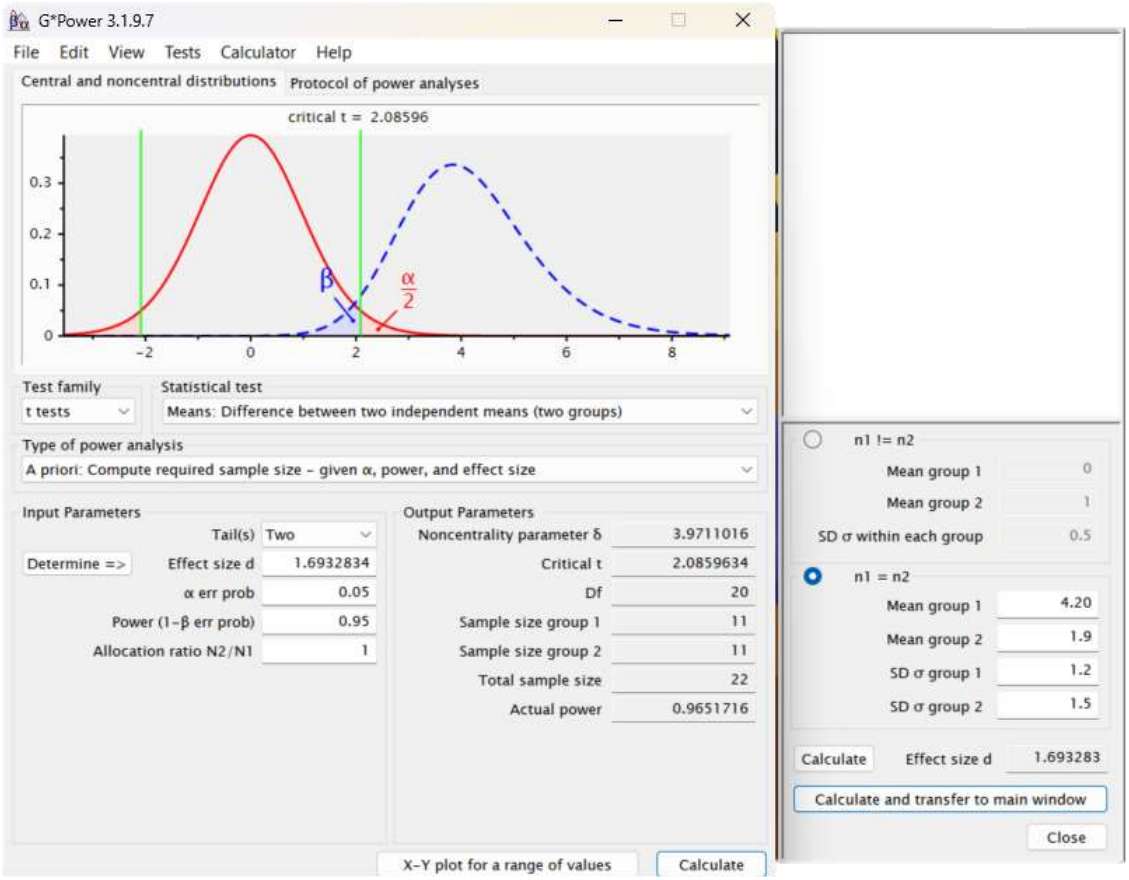
The primary endpoint will be postoperative length of stay (in days). Secondary endpoints will include total operating room time and procedure time, narcotic use (expressed as milligrams of oral morphine equivalents per day), use of adjuvant analgesia, side effects related to epidural analgesia or cryoanalgesia, visual analog pain scores, presence of neuropathic pain, presence and duration of thoracic numbness, procedure-related complications, and frequency of hospital readmissions within 30 days postoperatively.

Postoperative length of stay was selected as an objective measure that synthesizes multiple aspects of a procedure and its subsequent postoperative course, including adverse events, pain control, and psychosocial factors. This primary endpoint has also been used in other studies evaluating the effectiveness of cryoanalgesia in patients undergoing MIRPE. The adoption of other variables as the primary endpoint would require an initial pilot study, as there are no studies evaluating analgesic response using these variables as primary endpoints.

The study was designed to demonstrate a statistically significant effect (type I error rate of 0.05 and type II error rate of 0.05), based on preliminary studies demonstrating a reduction in hospital length of stay of approximately 2 days in participants undergoing cryoanalgesia.

Based on the results of Jaroszewski et al., which demonstrated a mean postoperative length of stay of 1.9 ± 1.5 days in the intervention group (intercostal cryoanalgesia) and 4.2 ± 1.2 days in the control group (thoracic epidural analgesia), sample size power calculation was performed with 1:1 allocation between the intervention and control groups using G*Power software version 3.1.9.7.

Figure 3 – Calculating the power of the study using randomization and 1:1 matching.



Accordingly, using a sample of 11 participants in the intervention group and 11 participants in the control group, the statistical power of the study would exceed 96% with a type I error rate of 0.05. Therefore, a total sample size of 40 participants will be used, maintaining 1:1 allocation, preserving study power even with potential losses of up to 45% in both groups.

Primary outcome data will be analyzed by comparing the median postoperative length of stay using the Mann–Whitney U test for nonparametric continuous variables. All other continuous variables will be analyzed by comparison of means using a two-tailed t test, while categorical data will be arranged in contingency tables and compared using the Pearson chi-square test.

Examinations and Description of Their Analysis

OUTPATIENT EVALUATION

Chest computed tomography – routine preoperative evaluation of patients with pectus excavatum, from which the Haller index will be derived.

Echocardiography – routine preoperative evaluation of patients with pectus excavatum, used to exclude the presence of concomitant cardiac malformations.

PREOPERATIVE EVALUATION FOR SURGICAL CANDIDATES

Complete blood count, coagulation profile, urea, creatinine, sodium, and potassium – routine laboratory tests performed in all surgical patients at the institution.

POSTOPERATIVE IMAGING STUDIES

Chest radiography – routine postoperative examination for all thoracic surgeries.

PROTOCOL ASSESSMENT METHODS

Visual Analog Scale (VAS) and Numeric Rating Scale (NRS) for pain – assessment methods performed in the postoperative period in both groups, without increasing hospitalization costs. Patient-reported outcomes included in the FDA BEST biomarker initiative will be evaluated regarding local and generalized pain intensity, pain duration, and pain exacerbation related to movement.

Daily postoperative opioid use will be calculated based on doses administered via oral, intravenous, and epidural routes, expressed as mg/kg/day. Fentanyl and hydromorphone will be converted to intravenous morphine-equivalent doses using standard equianalgesic conversion ratios (100 mcg of intravenous fentanyl = 10 mg of intravenous morphine; 1 mg of intravenous hydromorphone = 5 mg of intravenous morphine), and epidural-to-intravenous conversion ratios of 1:10 for morphine and 1:1 for fentanyl.

Patient-reported experience measures (PREMs) will be evaluated using the SSQ score at the sixth postoperative month.

Postoperative complications within 30 days will be evaluated using the Clavien–Dindo classification.

Total hospitalization cost will be assessed based on total values obtained from hospital billing performed by the hospital unit at the end of each admission. Costs will be stratified according to the sector in which they were incurred: inpatient ward, intensive care unit, and operating room. All values will be adjusted at the end of the study using official inflation data, corrected by the Brazilian National Consumer Price Index (IPCA/IBGE). Costs related to the donation of intercostal cryoablation probes and devices will not be included in the hospital cost calculation, as this procedure is not currently listed in the Brazilian Unified Health System (SUS) Table of Procedures, Medications, and Medical Devices.

Risks

There is a risk of loss of data confidentiality. However, measures will be implemented by the investigators to ensure the confidentiality of stored data.

There are reports in the literature of chronic pain and paresthesia following the use of intercostal cryoablation. Follow-up of participants for 12 months postoperatively will allow identification of and targeted intervention for this condition.

Other potential risks are associated with postoperative complications of thoracic surgery, including bleeding, surgical site infection, pneumothorax, pleural effusion, prolonged pleural drainage, reaction or rejection of implanted materials, displacement of metallic prostheses, and death.

Benefits

Reduction of postoperative pain and hospital length of stay in the period following surgery.

STUDY TIMELINE

PROCEDURES / ACTIVITIES BY SEMESTER	1st semester	2nd semes.	3rd semes.	4th semes.	5th semes.	6th semes.	7th semes.
Theoretical background	X	X					
Participant selection	X	X	X	X			
Assessment of inclusion and exclusion criteria	X	X	X	X			
Signing of informed consent/assent forms	X	X	X	X			
Surgical treatment		X	X	X	X		
Postoperative follow-up		X	X	X	X	X	X
Data collection		X	X	X	X	X	X
Presentation of results						X	X

This timeline was validated after approval by the Research Ethics Committee.

BUDGET

The present project will not generate costs for this institution, as it is a prospective study evaluating patients who are routinely treated surgically at the institution. The only additional devices to be used will be the probes for intraoperative intercostal cryoanalgesia, which will be donated by the company Novelty Comércio e Importação, according to the letter of agreement attached.

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