MARMARA
MEDICAL JOURNAL

Original Article

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Selective subxiphoid incision during MIRPE: Indications and outcomes

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Submitted: 28.10.2025 **Accepted:** 18.12.2025

ABSTRACT

Objective: This study assessed the utility of a selective subxiphoid incision during minimally invasive repair of pectus excavatum (MIRPE), emphasizing indications and early outcomes in patients at increased surgical risk.

Patients and Methods: Data from 39 patients were retrospectively analyzed, all of whom underwent MIRPE with an additional subxiphoid incision between August 2007 and May 2025. Data included demographics, deformity characteristics, surgical history, operative details, hospital stay, complications, and bar removal status.

Results: The mean age was 22.2 years (range 7–55), and 84.6% were male. The deformity was symmetric in 22 patients and asymmetric in 17. Indications for a subxiphoid incision included previous Ravitch (n=13) or MIRPE (n=14), severe pleural adhesions (n=6), prior sternotomy (n=2), and severe deformity (n=4). One bar was used in 25 patients, two in 11, three in 2, and four in 1. Mean operative time was 84.6 minutes, and mean hospital stay was 4.2 days. No intraoperative cardiac or pericardial injury occurred. Complications occurred in four patients (two wound revisions, two bar revisions). Bar removal was completed in 25 patients.

Conclusion: Adding a subxiphoid incision during MIRPE provides controlled retrosternal dissection and enhances safety in selected high-risk cases, particularly redo procedures and severe deformities.

Keywords: Pectus excavatum, MIRPE, Thoracoscopy, Subxiphoid approach

1. INTRODUCTION

Pectus excavatum (PE) represents the most frequent congenital deformity of the anterior thoracic wall, defined by a depression of the sternum and adjoining costal cartilages. First described by Donald Nuss in 1987, minimally invasive repair of pectus excavatum (MIRPE) rapidly transformed the surgical management of this deformity [1]. Our clinic has successfully performed MIRPE since its early years, and we previously reported our initial 5-year surgical series covering the period 2005-2010 [2].

The most critical step of MIRPE is the retrosternal tunneling, where limited visualization and adhesions may predispose to severe complications. Among these, cardiac perforation represents the most feared event, with several case reports documenting life-threatening or even fatal outcomes during bar introduction [3, 4]. Although rare, such reports emphasize the importance of preventive strategies and technical modifications to improve safety during this phase of the operation.

To minimize this risk, several technical modifications have been described, including sternal elevation techniques, bilateral thoracoscopy, external "crane" systems, and the use of a subxiphoid incision for retrosternal guidance [5-7]. The subxiphoid approach, either alone or in combination with sternal lift, provides direct protection of the heart and pericardium, facilitates adhesiolysis when necessary, and allows controlled retrosternal passage.

Early technical reports and small series have demonstrated that a subxiphoid incision can provide additional safety and control during retrosternal tunneling, particularly in challenging

How to cite this article: Cetinkaya C, Aslan S, Ermerak O N, Yuksel M. Selective subxiphoid incision during MIRPE: Indications and outcomes. Marmara Med J 2026;39(1): 46-49. doi: 10.5472/marumj.1873053

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ISSN: 1309-9469

http://doi.org/10.5472/marumj.1873053
Marmara Med J 2026;39(1): 46-49

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scenarios such as recurrent cases, rigid or severe deformities, and patients with prior sternotomy. These experiences underline the role of subxiphoid access as a selective adjunct when conventional MIRPE is considered high risk [8-10].

This study reports the institutional experience with MIRPE cases in which an additional subxiphoid incision was employed. The aim is to define the specific indications that necessitated this approach and to report the early postoperative outcomes of 39 consecutive patients in the context of the existing literature.

2. PATIENTS and METHODS

Study design and data collection

This retrospective study was conducted using a prospectively maintained database of 1,216 patients who underwent MIRPE between 2005 and 2025. From this cohort, we identified 39 patients in whom an additional subxiphoid incision was performed during MIRPE between August 2007 and May 2025. Patients who had previously undergone open chest wall repair (Ravitch procedure) or external compression repair (Abramson technique), which are based on different surgical principles than MIRPE, were excluded [11, 12]. Inclusion criteria comprised all patients undergoing MIRPE with subxiphoid incision, while those who had open procedures or Abramson repair were excluded. The following variables were collected: patient demographics (age, sex), deformity characteristics (symmetry or asymmetry), previous procedures (such as Ravitch or prior MIRPE), and the specific indications for adding a subxiphoid incision. Operative data included number of bars placed and operative time, while postoperative information comprised length of hospital stay, complications, and bar removal status. This study was approved by the Ethics Committee of Marmara University School of Medicine (Approval No: 09.2025.25-0713 Date:05.09.2025). All procedures were conducted in accordance with the principles of the Declaration of Helsinki.

Surgical technique

The standard MIRPE procedure as well as certain technical modifications have been described in detail in our earlier publications [13, 14]. In brief, two small lateral incisions were made along the anterior axillary lines, and a thoracoscope was introduced for intrathoracic visualization. A properly contoured bar was guided across the retrosternal space, rotated to elevate the sternum, and secured bilaterally with stabilizers. In selected patients, a small vertical subxiphoid incision was added. Through this incision, the surgeon's finger was introduced into the retrosternal space to perform blunt dissection of adhesions and to separate the pericardium from the posterior sternum before passage of the bar.

Postoperative management

In the early postoperative phase, intravenous patient-controlled analgesia (PCA) was administered, followed by intravenous analgesics during the first two days, and then continued until discharge with a switch to oral medication thereafter. Routine chest radiographs were obtained, and incentive spirometry was initiated to promote pulmonary expansion. Removal of the pectus bars was generally planned at approximately three years after insertion, with adjustments made according to patient age, deformity type, and severity.

3. RESULTS

Patient characteristics

The mean age of the patients was 22.2 ± 9.2 years (median 21, range 7–55). Most patients were male (33/39, 84.6%). The deformity was symmetric in 22 (56.4%) and asymmetric in 17 (43.6%) patients. Previous surgical repair had been performed in 27 cases, including 13 Ravitch and 14 prior MIRPE procedures, while 12 patients underwent primary repair. Patient demographics and preoperative characteristics, including deformity type and surgical history, are summarized in Table I.

Table I. *Patient characteristics and indications for subxiphoid incision*

Variable	Value
Number of patients	39
Age (years), mean (range)	22.2 (7-55)
Sex, n (%)	
Male	33 (84.6%)
Female	6 (15.4%)
Type of deformity, n (%)	
Symmetrical	22 (56.4%)
Asymmetrical	17 (43.6%)
Previous surgical history and other indications for subxiphoid incision, n (%)	
Ravitch	13 (33.3%)
MIRPE	14 (35.9%)
Severe pleural adhesions	6 (15.4%)
Previous sternotomy	2 (5.1%)
Severe deformity	4 (10.3%)

PE: Pectus excavatum; MIRPE: Minimally invasive repair of pectus excavatum

Indications for subxiphoid incision

The most common indication for adding a subxiphoid incision was a history of previous repair, which had resulted in dense retrosternal adhesions and fibrosis. This was observed in 13 patients with prior Ravitch procedures and in 14 patients with prior MIRPE. Additional indications included pleural adhesions in 6 patients, a history of median sternotomy for atrial septal defect repair in 2 patients, and severe or deep deformity in 4 patients. Representative cases of preoperative and postoperative appearance are presented in Figure 1.

Operative details

One bar was placed in 25 patients, two bars in 11, three bars in 2, and four bars in 1 patient. At the end of the procedure, a thoracic drain was inserted in 10 patients, while hemovac drains were used in 5 patients. The mean operative time was 84.6 ±

31.8 minutes (median 70, range 45–180). Intraoperative details, length of stay, bar removal status, and additional interventions are presented in Table II.

Table II. *Intraoperative and postoperative information*

Variable	Value
Number of bars, n (%)	
1 bar	25 (64.1%)
2 bar	11 (28.2%)
3 bar	2 (5.1%)
4 bar	1 (2.6%)
Mean duration of surgery (min), mean ± SD (range)	84.6 ± 31.8 (45–180)
Drain placement, n	
Chest tube	10
Hemovac	5
Mean length of stay (days), mean (range)	4.2 (2–7)
Bar removal status, n	
Removed	24 (61.5%)
Bar still in situ	15 (38.5%)
Additional procedures, n	
Wound revision	2
Bar revision	2
None	35

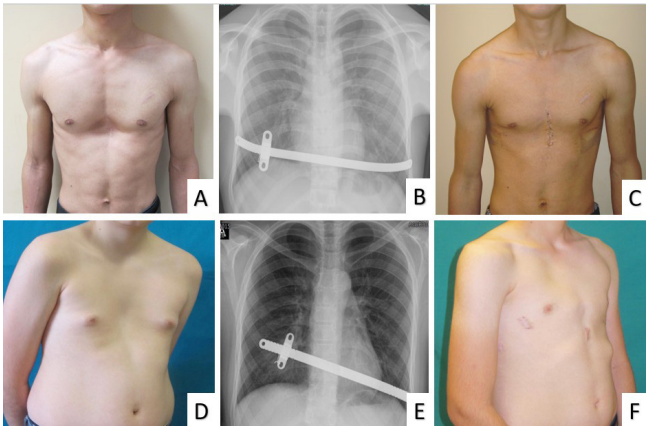


Figure 1. *Representative cases requiring subxiphoid incision during minimally invasive repair of pectus excavatum (MIRPE). (A–C) Patient with a history of failed Ravitch repair. (D–F) Patient with dense pleural adhesions.*

Postoperative outcomes

The mean length of hospital stay was 4.2 days (range 2–7). During follow-up, 25 patients underwent bar removal, including 24 at the planned time and 1 earlier due to wound infection. Complications were observed in 4 patients: 2 required wound revision for persistent drainage and 2 underwent bar revision. The remaining 35 patients had an uneventful postoperative course.

4. DISCUSSION

Pectus excavatum is the most common congenital chest wall deformity, traditionally repaired with the open Ravitch procedure for several decades until the introduction of the minimally invasive repair by Nuss in 1998 [1]. While MIRPE rapidly gained popularity due to its less invasive nature and favorable cosmetic outcomes, the retrosternal tunneling step carries unique risks, particularly the possibility of cardiac or pericardial injury, which, although rare, can be life-threatening [3, 15, 16]. To mitigate these risks, several adjuncts have been described, including bilateral thoracoscopy [17], sternal elevation with a crane system [7], and the addition of a subxiphoid incision for finger-guided retrosternal dissection [5, 8]. In the present study, we report the institutional experience with the use of a subxiphoid incision during MIRPE.

Previous reports, including both small case series and larger cohorts, have demonstrated that adding a subxiphoid incision provides a safer passage of the bar by enabling blunt finger dissection to separate the pericardium from the posterior sternum and to release adhesions [5, 8, 9]. While this approach facilitates controlled guidance of the introducer across the mediastinum, its main drawback is the presence of a small but more visible anterior incision. In our series, we similarly employed this maneuver, using the subxiphoid access to elevate the sternum digitally and allow a secure passage of the bar. As highlighted by Liang Guo and colleagues, redo procedures after failed Ravitch or previous Nuss repair are technically challenging due to dense retrosternal fibrosis and adhesions, which increase the risk of complications [8]. In such cases, the addition of a subxiphoid incision allows safe finger dissection to separate adhesions and create a controlled retrosternal space.

Our study represents one of the largest cohorts to date, including 39 patients who underwent MIRPE with the addition of a subxiphoid incision between August 2007 and May 2025. In this group, the main indications for adding a subxiphoid incision were systematically defined, namely prior Ravitch procedures, previous MIRPE, severe deformities, history of sternotomy, and dense pleural adhesions. These scenarios illustrate situations where a subxiphoid incision may be considered to facilitate safe and controlled bar passage, and our findings support its practical applicability in such challenging cases.

This study has certain limitations. The retrospective nature of the analysis introduces inherent biases, and although follow-up ranged from 5 to 218 months, bar removal had been completed in 25 of the 39 patients at the time of analysis. Therefore, long-term outcomes following bar removal could not be fully assessed. Future prospective studies with extended follow-up and complete bar removal data would be valuable to better define the role and durability of this approach.

http://doi.org/10.5472/marumj.1873053
Marmara Med J 2026;39(1): 46-49

Conclusion

In conclusion, the addition of a subxiphoid incision during MIRPE can serve as a safe adjunct in selected patients, particularly in redo procedures and in cases with severe or complex deformities. This modification provides a straightforward means of controlled retrosternal dissection and may help reduce the risk of life-threatening complications.

Compliance with Ethical Standards

Ethical approval: This study was approved by the Ethics Committee of Marmara University School of Medicine (Approval No: 09.2025.25-0713 Date:05.09.2025). All procedures were conducted in accordance with the principles of the Declaration of Helsinki.Written informed consent was obtained from all patients prior to the procedure.

Conflict of interest: The authors declare that there is no conflict of interest.

Financial support: This study received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Author Contributions: CC and MY: Conception or design of the manuscript,

CC, NOE and SA: Data collection, CC and NOE: Data analysis and interpretation,

CC: Drafting the manuscript. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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