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CLINICAL EFFECTIVENESS OF PREOPERATIVE VACUUM THERAPY IN THE CORRECTION OF PECTUS EXCAVATUM IN ADOLESCENTS USING THE D. NUSS THORACOPLASTY TECHNIQUE

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Abstract

Pectus excavatum is the most common congenital deformity of the chest wall, accounting for up to 85–90% of all thoracic deformities. In addition to cosmetic concerns, this condition may cause functional impairment of the respiratory and cardiovascular systems, particularly during adolescence. Surgical correction using the D. Nuss thoracoplasty technique is widely accepted as the gold standard; however, it is often associated with significant postoperative pain, prolonged rehabilitation, and the risk of metal bar displacement.

The present study aimed to evaluate the clinical effectiveness of preoperative vacuum therapy in adolescents with pectus excavatum undergoing correction using the D. Nuss thoracoplasty technique. Special attention was paid to intraoperative facilitation, reduction of operative time, postoperative pain severity, duration of analgesic therapy, length of hospital stay, and postoperative complications.

A retrospective analysis was performed on 237 patients aged 8–19 years who underwent surgical correction of pectus excavatum at the Republican Pediatric Orthopedic Center between 2020 and 2025. Among them, 98 patients were adolescents older than 12 years. Preoperative vacuum therapy for two months was applied in 29 patients. The vacuum device was initially used for 5 minutes per day, with gradual extension up to 6 hours daily. All patients underwent comprehensive preoperative evaluation, including echocardiography, spirometry,

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cardiology consultation, and multislice computed tomography. Deformity severity corresponded to grade II–III according to the Kondrashin classification, with a mean Haller index of 5.85. Surgical correction was performed using the D. Nuss technique.

Preoperative vacuum therapy resulted in increased chest wall mobility, which significantly facilitated the surgical procedure. Operative time was reduced to 35–45 minutes compared to 60–75 minutes in patients without vacuum therapy. Postoperative pain was less pronounced, requiring shorter use of narcotic and nonsteroidal anti-inflammatory analgesics. No cases of metal bar displacement were observed in the vacuum therapy group, while such complications occurred in patients without vacuum therapy. Additionally, the length of hospital stay was shorter in patients who received preoperative vacuum therapy.

Preoperative vacuum therapy is a safe and effective adjunctive method that improves surgical outcomes, reduces postoperative pain, shortens hospitalization, and optimizes rehabilitation in adolescents undergoing D. Nuss thoracoplasty for pectus excavatum.

Keywords: Pectus excavatum; adolescents; preoperative vacuum therapy; D. Nuss thoracoplasty; chest wall deformity; surgical outcomes

Introduction

Pectus excavatum is the most frequently encountered congenital deformity of the chest wall and represents a significant proportion of thoracic skeletal abnormalities in pediatric and adolescent populations. The condition is characterized by a posterior depression of the sternum and adjacent costal cartilages, leading not only to visible chest wall asymmetry but also to potential functional disturbances. During adolescence, when rapid somatic growth and increased physical demands occur, the clinical significance of this deformity becomes more pronounced.

Although pectus excavatum is often initially perceived as a cosmetic defect, numerous clinical observations indicate its association with impaired respiratory mechanics and altered cardiovascular function. Reduced chest wall compliance,

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decreased lung volumes, and displacement or compression of cardiac structures may contribute to exercise intolerance, fatigue, and reduced quality of life. These functional limitations are particularly relevant in adolescent patients, for whom physical activity and psychosocial adaptation play a crucial role in overall development.

Surgical correction remains the primary treatment modality for moderate to severe forms of pectus excavatum. Among various operative techniques, the minimally invasive D. Nuss thoracoplasty has gained widespread acceptance and is currently regarded as the gold standard for correction. The method allows effective elevation of the depressed sternum with relatively limited surgical trauma and satisfactory cosmetic outcomes. However, despite its advantages, the D. Nuss procedure is frequently accompanied by notable postoperative pain, extended rehabilitation periods, and the risk of metal bar displacement, especially in patients with rigid or poorly mobile chest walls.

Chest wall rigidity is considered one of the key factors complicating intraoperative manipulation and postoperative recovery in adolescent patients. Increased resistance of the thoracic cage may prolong operative time, intensify postoperative pain, and elevate the likelihood of complications. Consequently, strategies aimed at improving chest wall flexibility prior to surgical intervention have attracted growing clinical interest.

Preoperative vacuum therapy has emerged as a non-invasive method capable of gradually mobilizing the chest wall by applying controlled negative pressure to the anterior thoracic surface. By increasing the elasticity and mobility of the sternocostal complex, vacuum therapy may facilitate surgical correction, reduce intraoperative technical difficulties, and improve postoperative outcomes. Nevertheless, clinical data regarding the effectiveness of preoperative vacuum therapy as an adjunct to D. Nuss thoracoplasty in adolescents remain limited and require systematic evaluation.

In this context, the present study focuses on assessing the clinical effectiveness of preoperative vacuum therapy in adolescents undergoing correction of pectus excavatum using the D. Nuss technique. Emphasis is placed on its impact on

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surgical complexity, operative duration, postoperative pain severity, rehabilitation course, and the incidence of postoperative complications.

Materials and Methods

This study was conducted at the Republican Pediatric Orthopedic Center and is based on a retrospective analysis of clinical outcomes in patients with pectus excavatum who underwent surgical correction between 2020 and 2025. A total of 237 patients aged from 8 to 19 years were treated surgically during the study period. Among them, 67 patients were female and 170 were male. Adolescents aged over 12 years constituted a subgroup of 98 patients and represented the main focus of the present analysis.

All patients included in the study were diagnosed with pectus excavatum based on clinical examination and instrumental assessment. The severity of chest wall deformity corresponded to grade II or III according to the Kondrashin classification. Morphological severity was additionally evaluated using multislice computed tomography, with the mean Haller index recorded at 5.85. Preoperative functional assessment included echocardiography, spirometry, and cardiology consultation in all cases.

Within the adolescent subgroup, 29 patients underwent preoperative vacuum therapy prior to surgical correction. Vacuum therapy was applied for a duration of two months before the planned operation. The vacuum device was initially used for 5 minutes per day, with a gradual and controlled increase in application time up to 6 hours per day. The remaining adolescent patients did not receive vacuum therapy and served as a comparative group.

Surgical correction of pectus excavatum was performed in all patients using the minimally invasive D. Nuss thoracoplasty technique. Intraoperative parameters included operative duration and technical complexity of bar insertion. Postoperative evaluation focused on pain intensity and duration, the need for narcotic and nonsteroidal anti-inflammatory analgesics, length of hospital stay, and the occurrence of postoperative complications, particularly metal bar displacement.

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Postoperative pain management protocols were analyzed by recording the duration of narcotic analgesic use and subsequent nonsteroidal anti-inflammatory drug administration. Hospitalization time was calculated from the day of surgery to discharge. Complications were identified through clinical observation and follow-up during the inpatient period.

Comparative analysis was performed between adolescents who received preoperative vacuum therapy and those who did not, with emphasis on operative time, postoperative pain control, length of hospital stay, and complication rates.

Results

During the study period from 2020 to 2025, surgical correction of pectus excavatum using the D. Nuss thoracoplasty technique was performed in 237 patients at the Republican Pediatric Orthopedic Center. Among them, 98 patients were adolescents aged over 12 years and were included in the detailed analysis. Within this adolescent group, 29 patients received preoperative vacuum therapy for two months prior to surgery, while the remaining patients underwent surgical correction without vacuum therapy.

In patients who received preoperative vacuum therapy, a noticeable increase in chest wall mobility was observed prior to surgery. This improvement significantly facilitated intraoperative manipulation, including easier passage of the introducer and positioning of the metal bar. Reduced resistance of the thoracic cage allowed the surgical procedure to be performed with less technical difficulty.

The operative time differed markedly between the two groups. In the vacuum therapy group, the duration of surgery ranged from 35 to 45 minutes. In contrast, patients who did not receive vacuum therapy required a longer operative time, ranging from 60 to 75 minutes. Thus, preoperative vacuum therapy was associated with a substantial reduction in surgical duration.

Postoperative pain intensity and analgesic requirements also demonstrated significant differences between the groups. Patients who underwent preoperative vacuum therapy required narcotic analgesics only during the first postoperative day, followed by nonsteroidal anti-inflammatory drugs for 2–3 days. After this period, pain intensity decreased to a level that did not necessitate further analgesic

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use. In comparison, patients without vacuum therapy required narcotic analgesics for two postoperative days and continued nonsteroidal anti-inflammatory drug therapy for 7–10 days.

The incidence of postoperative complications further highlighted the benefits of preoperative vacuum therapy. Metal bar displacement was not observed in any of the 29 patients who received vacuum therapy. Conversely, bar displacement occurred in two patients from the group that did not undergo vacuum therapy prior to surgery.

Length of hospital stay also varied between the groups. Patients treated with preoperative vacuum therapy had a shorter postoperative hospitalization period, averaging 4–5 days. In contrast, patients who did not receive vacuum therapy remained hospitalized for 7–10 days.

Overall, the results demonstrate that preoperative vacuum therapy positively influenced intraoperative conditions, reduced operative time, alleviated postoperative pain, shortened hospitalization, and decreased the risk of postoperative complications in adolescents undergoing D. Nuss thoracoplasty for pectus excavatum.

Discussion

The results of the present study demonstrate that preoperative vacuum therapy plays a significant supportive role in the surgical management of pectus excavatum in adolescent patients undergoing correction with the D. Nuss thoracoplasty technique. The observed clinical benefits are primarily associated with improved chest wall mobility achieved prior to surgery, which directly influenced both intraoperative and postoperative outcomes.

One of the key findings of this study is the marked reduction in operative time in patients who received preoperative vacuum therapy. Increased flexibility of the sternocostal complex reduced resistance during introducer passage and metal bar placement, thereby simplifying the technical aspects of the procedure. In adolescent patients, chest wall rigidity is often more pronounced due to advanced skeletal maturation, which may complicate surgical correction. The present

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results suggest that vacuum therapy effectively mitigates this challenge by gradually mobilizing the thoracic cage before surgery.

Postoperative pain management represents a critical aspect of recovery following D. Nuss thoracoplasty. Severe pain is a well-recognized limitation of this procedure and often necessitates prolonged use of narcotic analgesics. In the current study, patients who underwent preoperative vacuum therapy required significantly shorter courses of both narcotic and nonsteroidal anti-inflammatory analgesics. Reduced postoperative pain intensity may be attributed to decreased intraoperative mechanical stress on the chest wall and surrounding tissues, resulting from improved deformity compliance at the time of correction.

Another clinically relevant observation is the absence of metal bar displacement in patients who received vacuum therapy. Bar displacement is a potentially serious complication that may necessitate reoperation and prolong recovery. Improved chest wall adaptability and more stable bar positioning at the time of surgery may contribute to the lower incidence of this complication in the vacuum therapy group. In contrast, bar displacement was observed exclusively in patients who did not undergo preoperative vacuum therapy.

The shorter length of hospital stay observed in the vacuum therapy group further reflects the overall improvement in postoperative recovery. Reduced pain, fewer complications, and earlier functional recovery collectively contributed to faster discharge from the hospital. From both clinical and healthcare system perspectives, this outcome is particularly important, as it reduces the burden on inpatient services and improves patient quality of life.

Taken together, these findings support the integration of preoperative vacuum therapy into the treatment algorithm for adolescents with pectus excavatum scheduled for D. Nuss thoracoplasty. The therapy appears to be safe, non-invasive, and well tolerated, while providing measurable benefits across multiple clinical parameters. Although the present study is limited to retrospective analysis, the consistency of observed improvements underscores the clinical relevance of vacuum therapy as an adjunctive preoperative strategy.

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Conclusion

The findings of this study demonstrate that preoperative vacuum therapy is an effective and safe adjunctive method in the surgical correction of pectus excavatum in adolescent patients undergoing D. Nuss thoracoplasty. Application of vacuum therapy for two months prior to surgery significantly improves chest wall mobility, which facilitates intraoperative manipulation and reduces technical complexity.

Preoperative vacuum therapy was associated with a substantial reduction in operative time, decreased postoperative pain intensity, and a shorter duration of analgesic use. Additionally, patients who received vacuum therapy experienced fewer postoperative complications, with no cases of metal bar displacement observed in this group. The length of postoperative hospitalization was also notably reduced, indicating faster recovery and optimized rehabilitation.

Overall, incorporating preoperative vacuum therapy into the treatment protocol for adolescents with pectus excavatum enhances the clinical effectiveness of the D. Nuss thoracoplasty technique. This combined approach not only improves surgical outcomes but also contributes to a less painful postoperative course and a quicker return to normal activity. The results support the use of vacuum therapy as a reliable and clinically beneficial preoperative strategy in the comprehensive management of pectus excavatum in adolescent patients.

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