CLINICAL CHARACTERISTICS AND EARLY RESULTS OF THE MODIFIED ABRAMSON TECHNIQUE TO TREAT PECTUS CARINATUM AT VIET DUC HOSPITAL FROM 2020-2023

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Pectus carinatum is the second most common congenital anterior chest wall deformity. This study describe the clinical, paraclinical characteristics and evaluate the early results of the modified Abramson technique to treat pectus carinatum at Viet Duc Hospital. This is a retrospective descriptive study, in all cases diagnosed with pectus carinatum and underwent surgery according to the modified Abramson technique at Viet Duc Hospital from 1/2020 to 12/2023. In 134 patients, 131 were male, the mean age 13.6 ± 1.98 years. All patients presented with cosmetic complaints, and 85.2% patients have BMI <18.5. 94/134 cases (70.2%) had symmetrical deformities, 37/134 cases (27.6%) had asymmetrical deformities, and 3 cases (2.2%) had mixed pectus deformities. The average Haller index is 2.1 ± 0.3. All patients were operated using a bar, fixed at both ends with steel thread. Operative time was 33.6 ± 7.76 minutes, and hospital stay was 5.3 ± 0.76 days (4–7 days). There was no significant early postoperative complications. Conclusion: clinical examination and computed tomography play an important role in diagnosing pectus carinatum. The modified Abramson technique is a minimally invasive surgical method for pectus carinatum patients with short operative time, hospital stay, and the first step gives good treatment results.

Keywords: Pectus carinatum, modified Abramson technique, Hanoi medical University.

I. INTRODUCTION

Pectus carinatum is an outward protrusion deformity of the sternum and adjacent costal cartilages. It is the second most common congenital deformity of the anterior chest wall and commonly occurs in adolescents. In most cases, it first appears at about 10 years old and peaks at ages 16-18. It usually occurs in males, with an incidence of approximately 1/1000 individuals. The pathogenesis of pectus carinatum remains unknown, but a genetic predisposition is suspected since approximately 25% of pectus carinatum patients have a family history of chest wall deformities. Most patients with pectus carinatum are asymptomatic. However, together with the aesthetic concerns, pectus carinatum can lead to physical symptoms, significant psychological distress, and a reduced quality of life. That is the main reason for the treatment requirements of most patients.

The treatment modalities of pectus carinatum may be either surgical or non-surgical (bracing), and surgical treatments are either resective or non-resective. Minimally invasive surgery using the Abramson method has been around since the 2000s and has proven to be effective, safe and widely applied worldwide.[1,2] This method is a non-resective technique and uses a presternally placed metal bar to compress the sternum; the bar is fixed to both sides of the chest wall using metal plates.

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Then, many different modified versions by many authors around the world based on the principles of Abramson surgery have also been proposed. At Viet Duc Hospital, the Abramson technique was modified with changes for suitable practical circumstances and available equipments. Modified technique compared to the original surgery include a small incision at the midclavicular line on both sides, the use of a short bar placed in a tunnel under the skin of the chest wall. Futher, simple fixation with steel wire sewn around the ribs, with an opening into the pleural cavity. Therefore, we conducted this study to review the clinical characteristics as well as evaluate the early results achieved in patients with Pectus carinatum who were operated on with the modified Abramson technique at Viet Duc Hospital in 2020-2023, from which to make initial assessments on the safety and effectiveness of surgical treatment of patients with pectus carinatum.

II. MATERIALS AND METHODS

1. Materials of the study

All the patients with pectus carinatum being operated by the modified Abramson technique at Viet Duc Hospital from 1/2020 to 12/2023.

Methods of the study

Retrospective descriptive study.

Sampling method

Convenience sampling (134 patients).

The research indexes

Pre-operation: age, gender, BMI, clinical characteristics, type of pectus carinatum, the Haller index; the indexes in surgery: operative time, Incidence ; and the postoperative indexes: hospitalization duration, chest X-Rays, early postoperative complications (infection, bleeding, pneumothorax...).

2. Research process and data processing

Data were collected according to medical records and processed with SPSS 20.0.

3. Ethics of research

All subjects gave their informed consent for inclusion before they participated in the study. All information is confidential and used for research purposes only

III. RESULTS

1. The clinical, paraclinical characteristics

The majority of the patients were male (131 males, 3 females), and the median patient age was 13.6 ± 1.98 years (6-23 years olds). There were 128/134 patients (95.5%) aged between 10-18 years old, 5 patients were under 10 years old and the oldest patient was 23 years old (Figure 1).

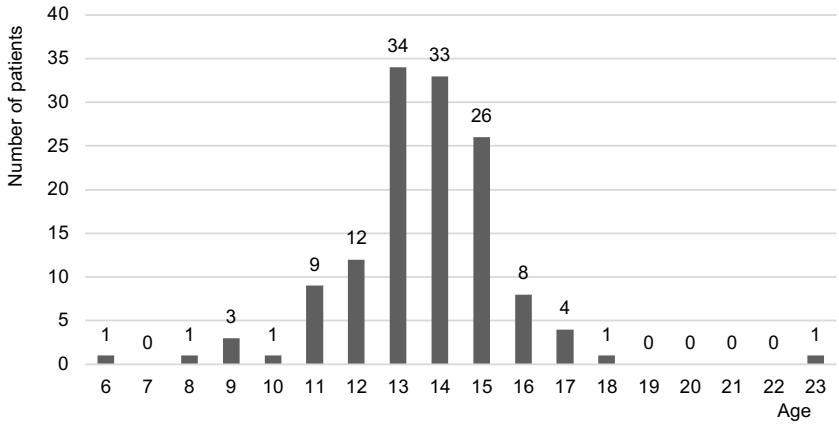

Figure 1. Age distribution of the study population

100% of the patients were presented to our clinic because of cosmetic complaints, which affected the patient's psychology. Cosmetic complaints and protrusion of the chest are the most discomforts. The patients showed signs of underdeveloped physical, with an average BMI in the study of 16.6 ± 1.95 (min:12.49, max:22.89). There were 114/134 (85.1%) patients with a BMI < 18.5, the threshold for underweight. In the healthy weight range with a BMI from 18.5 to 25, there were 20 patients, accounting for 14.8%. There was no patient with a BMI >25.

About the clinical classification of pectus carinatum, 94/134 cases (70.2%) were symmetrical deformities, 37/134 cases (27.6%) were asymmetrical deformities, and 3 cases (2.2%) had mixed pectus deformities, which were a combination of both pectus excavatum and carinatum (Figure 2).

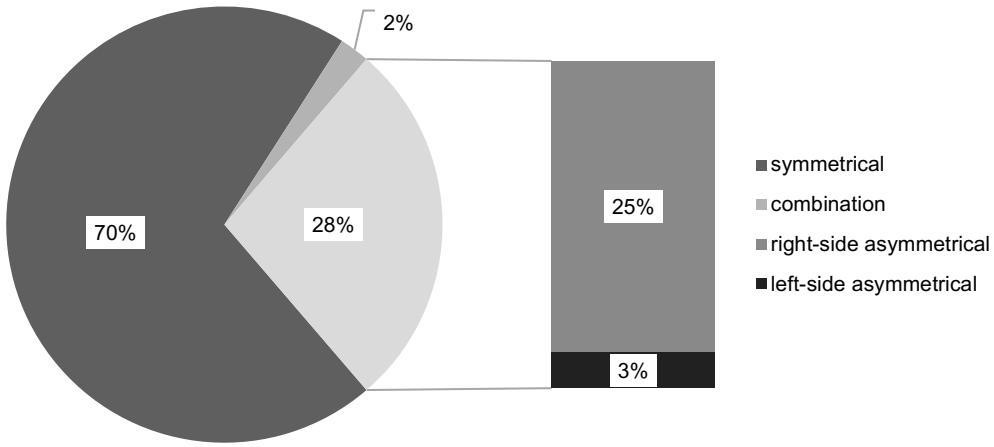

Figure 2. The clinical classification of pectus carinatum of the study population

In the paraclinical characteristics, there was 1 case of patent foramen ovale and 1 case of coarctation of the aorta by echocardiography. 128/134 patients had Haller index (HI) measured on a computed tomography scan, and the average HI in the study was 2.1 ± 0.3. 13/128 patients (10.2%) had HI < 1.8, which was very severe pectus carinatum (table 1).

Table 1. Distribution of study population according to HI's classes

HI	N (n = 128)	%
HI < 1.8	13	10.2%
1.8≤ HI ≤2.2	86	67.2%
HI > 2.2	29	22.7%

2. The early postoperative results

The surgical procedure using the Abramson technique was uniform for all patients in the study. The operative time was 33.6 ± 7.76 minutes (20-62 minutes). All patients had a bar placed outside the chest and fixed at both ends with double steel threads. There were no complicationduring the surgery.

The average hospital stay was 5.3 ± 0.76 days (range: 4 - 7 days). All patients received 3 days of

maintenance epidural analgesia combined with intravenous paracetamol analgesia. There was no significant early postoperative complication. Through post-operative chest X-rays, 9 patients (6.7%) had pneumothorax, of which all were treated conservatively without surgery. In 2/9 cases of large pneumothorax, the pleural space was aspirated with a needle through the II intercostal space, and the outcome was stable. There were no complication such as bleeding, infection, or death after surgery.

IV. DISCUSSION

Since 1952, the cornerstone of treatment for pectus carinatum has been the operation, as initially described by Ravitch.[3] Numerous extensive series have described the method and results for this initial operational correction of pectus carinatum since the first description. An anterior midline or transverse incision is made, the pectoralis muscles are raised off the sternum and thoracic cage, the implicated costal cartilages are resected, and usually at least one sternal osteotomy is performed to allow the sternum to be repositioned. The sternum has been fastened at the appropriate height using stainless steel wire or mesh to provide extra sternal support. These were highly invasive techniques, had a risk of bleeding, many complications and left large surgical scars.[4] A substitute for open surgery was proposed by Abramson et al. for specific patients whose chest walls exhibited good flexibility. The patient would have a higher appreciation of the cosmetic outcome because this method only requires two minor incisions in the lateral area of the chest. However, not all types of pectus carinatum were suitable for the Abramson technique, typically pigeon-chest with excessively rigid ribs and rib cartilage were not suitable for this method. For patients with classic or asymmetrical pectus carinatum, the Abramson technique had proven to be effective, safe and brings high aesthetics to the patient.[2]

A decisive factor in the success of surgery is the flexibility of the chest wall, which is inversely proportional to the patient's age. Therefore, the patient's age at the time of surgery is very important. Yuksel et al. reported that, 11-20 years of age was optimal because the chest wall is more flexible in puberty.[5] In 2018, Yuksel et al. announced surgery in 172 patients over 10 years old, giving very good results in 93.8% of patients.[6] In our study, the age range from 10 to 18 years old accounted for 95.5%, and the average age of the study was 13.6 ±1.98 years old, with only 1 elderly patient being 23 years old (Figure 1). Similarly, Apaydin et al. patients had an average age of 14.4±7.8 years (8-25 years old).[7] The patients in our study showed signs of physical underdevelopment, with an average BMI of 16.6 ± 1.95. There were 114/134 (85.1%) patients with a BMI < 18.5 which is the threshold for underweight (Figure 3). There have been no study evaluating this issue, however, with thoracic deformities in general, there have been comparative studies showing that BMI in the thoracic deformity group is significantly lower than in people of the same age.[3,4]

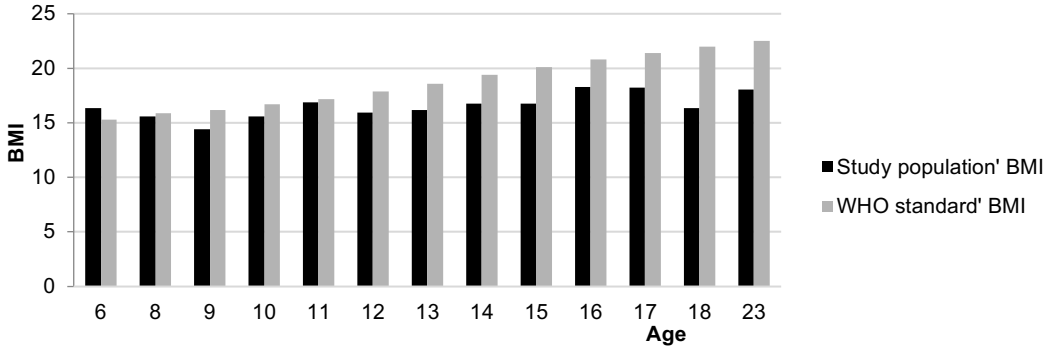

Figure 3. Comparison of BMI according to age of the study population with WHO standards

Between the ages of 12-17, the BMI of the study subjects was statistically significantly lower than the WHO standard with $p < 0.05$ (Table 2).

Table 2. Evaluate the correlation between BMI according to age of study population with WHO standards using One-Sample T-Test

Age	Study population' BMI	WHO standard' BMI	p < 0.05
6	16.3	15.3	-
8	15.6	15.9	-
9	14.4	16.2	0.133
10	15.6	16.7	-
11	16.9	17.2	0.681
12	16.0	17.9	**0.003**
13	16.2	18.6	**<0.001**
14	16.7	19.4	**<0.001**
15	16.8	20.1	**<0.001**
16	18.3	20.8	**0.014**
17	18.2	21.4	**0.035**
18	16.3	22	-
23	18.1	22.5	-

Regarding clinical characteristics, all patients came to the clinic because of cosmetic complaints. Chest pain and shortness of breath are rare. This is similar to other studies such as Katrancioglu in 2018, Rimessi in 2021.[5,6] *The classification of pectus carinatum was assessed through clinical examination, 94/134 cases (70.2%) had symmetrical deformities, 37/134 cases (27.6%) had asymmetrical deformities, and 3 cases (2.2%) had mixed pectus deformities, which were a combination of both pectus excavatum and carinatum.*

The Haller index (HI) has a difference in calculation between pectus excavatum and

pectus carinatum. With pectus carinatum, HI based on the images on the CT scan to objectify the severity of the malformation, this index is calculated by dividing the width of the chest by the distance between the sternum and spine; the lower this value, the more severe the malformation. The HI for the diagnosis of pectus carinatum range from 1.8 to 2.2 while for severe PC patients, this index is less than 1.8.[12] The average HI in the study was 2.1 ± 0.3. The lowest was 1.6 and the highest was 2.68. 13/128 patients (10.2%) had HI < 1.8, which was very severe pectus carinatum. This result is similar to the study by author Park HJ in 2016[7], but higher than that of two authors, Barbara Del Frari (2021)[8] and Xuefeng Zhang (2022)[9], but there is no significant difference (Table 3).

According to Ziyin Shang, indications for pectus carinatum surgery should be applied in cases where the patient has one of the following factors: clinically obvious deformity, aesthetic or psychological impact, and HI lower than 2.3.[10] Also, according to this author, the failure rate in the non-surgical treatment group increased with age, and failure reached 85% in the group of 12-15 years old patients in a study of 767 patients.

Table 3. Compare Haller index in other studies

Haller Index	Our study (n=134)	Park HJ 2016[7] (n=16)	Barbara Del Frari 2021[8] (n=14)	Xuefeng Zhang 2022[9] (n=112)
Average before surgery	2.1 ± 0.3	2.04 ± 0.34	1.97 ± 0.38	1.96 ± 0.22
Min	1.6	NA	1.6	NA
Max	2.68	NA	2.7	NA
Average after surgery	NA	2.54 ± 0.29	2.16 ± 0.3	2.78 ± 0.35

The chest was measured preoperatively and appropriately sized bars were chosen. Patients in the study were given a bar with a minimum length, equal to the distance connecting the two anterior axillary lines on both sides. The bar was fixed to the ribs with double steel threads at both ends, and opened into the pleural cavity. The average operative time in the study was 33.6 ± 7.76 minutes, lower than other studies (Table 4) such as Yuksel's *operative* time of 76 minutes, Xuefeng Zhang's of 67 minutes[6,9] since we have been performing this surgery since 2016, and have improved the technique, using fixed steel threads instead of fixation plates like other authors who followed the original technique. Another factor is that we go directly into the pleural cavity, which did not take much time for dissection to preserve the parietal pleura, thereby shortening the surgery time. Using a short bar also reduces the time it takes to bend the bar to conform to the desired ribcage shape.

Figure 4. Twelve year old, male patient, before and after surgery

Improving and changing some small steps in surgery helps shorten surgery time, without increasing the rate of complications. All patients had no complication during surgery. Carefully stopping the bleeding and entering the pleural cavity at the upper edge of the ribs, where there are no intercostal neurovascular bundles, helps minimize the risk of per-postoperative bleeding. Gas from the outside environment passes through the opening into the pleural cavity, causing pneumothorax, which is actively controlled by expelling air, combined with balloon inflation by the anesthesiologist to help limit the risk of postoperative pneumothorax. The rate of complications from pneumothorax and subcutaneous emphysema in our study was 6.7%. There were no postoperative bleeding complication. In the initial technique, preserving the parietal pleura was very important, however, because it was very thin, making sure it was not torn was also difficult and time-consuming, and not proactively expelling air in the pleural cavity at the end of surgery may be the reason for longer surgery as well as increasing the rate of pneumothorax, as in other authors' studies.

Table 4. Compare indicators during surgery and the postoperative period

Indicator	Our study (n=134)	Apaydin 2021[11] (n=64)	Xuefeng Zhang[9] 2022 (n=112)	Yuksel M 2018[12] (n=172)
Operative time (minutes)	33.6 ± 7.76	61	67.74	76
Pneumothorax	6.7%	4.6%	10%	7% -2.9%
Hospital stay (day)	5.3 ± 0.76	5.1 ± 2.9	3.64	3.7

Regarding other complications such as hemothorax and surgical wound infection, in our study, because the recording time was from the time the patient had surgery to the time they

were discharged from the hospital, no case was recorded. This is similar to the results of other authors. Complications often appear late, and the most common include broken steel threads, loose steel threads, bar displacement, bar allergy, recurrence, or development into pectus excavatum.[6,7,9]

The hospitalization duration in our study was 5.3 ± 0.76 days (3-7 days). This time was similar to the results of Apaydin (2021) of 5.1 ± 2.9 days, but was longer than other studies such as Xuefeng Zhang (3.64 days) and Yuksel (3.7 days). To explain this problem, all patients received 3 days of maintenance epidural analgesia combined with intravenous paracetamol analgesia. The patient was then re-examined with a chest X-ray on day 4 and discharged from the hospital on day 5 if no serious complicationoccurred. Therefore, the shortest hospital stay was 4 days. In particular, there were cases of pneumothorax to be monitored, which resulted in longer hospital stays lasting up to 7 days.

V. CONCLUSION

Clinical indicators play an important role in assessing preoperative patients with pectus carinatum, classifying the type of pectus carinatum and predicting treatment. The modified Abramson technique at Viet Duc Hospital has proven its effectiveness, safety and brought positive results.

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