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Early Results of Video-Assisted Thoracoscopic Surgery in Left-to-Right Nuss Procedure for Pectus Excavatum

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Abstract

Objective: This study aimed at evaluating the efficacy and safety of Video-Assisted Thoracoscopic Surgery (VATS) in left-to-right Nuss procedure for the treatment of pectus excavatum.

Subjects and methods: Our study included 111 patients diagnosed with pectus excavatum who underwent VATS in left-to-right Nuss procedure. Patient's age ranged from 3–23 years old (mean: 15.65 ± 3.25); male/female ratio: 6,4/1. This is a prospective study which was conducted from February to August 2018.

Results: Moderate and severe pectus excavatum accounted for 63.06% and 36.04% of our study cohort, respectively. The mean operation time was 48 ± 18 minutes; the mean post-operative length of stay was 4.93 ± 1.12 days. No severe complication or death occurred. Left thoracoscopy provided a better observation of the thoracic cavity and mediastinum so we could avoid injuring the heart, the lungs, vessels, and the diaphragm. The process to create the tunnel from the left to the right side of the chest through the mediastinum was convenient, quick, safe and superior to approaching from the right to the left side.

Conclusion: VATS in left-to-right Nuss procedure for the treatment of pectus excavatum has many advantages: it is convenient, safe, effective, and it has high success rate with low complication rate.

Background

Pectus Excavatum is a congenital deformity of the anterior chest wall in which the sternum and the bilateral ribs cartilages develop abnormally leading to a sunken chest. This is the most common chest deformity which affects an estimated 1/400 to 1/300 live new-borns (in the United States) with a male to female ratio of 4:1 [1–4]. Many types of surgeries have been proposed to treat this congenital funnel chest, such as Ravitch surgery (1949), Bruner surgery [1,5] etc. Nuss procedure-first performed in 1986 by Donald Nuss for the treatment of pectus excavatum and showed good results-has been rapidly adapted and increasingly performed worldwide [3]. The classical Nuss procedure does not use thoracoscopy and access the thorax from the right side [3]. To date, there are many advances in this procedure, especially the application of thoracoscopy in Nuss procedure has been widely accepted and commonly applied. Current discussions mainly focus on the benefit of approaching the thorax from the left, right side, or both; and the need of CO_2 insufflation or raising the sternum to ensure the safety during surgery. This study was conducted with the aim to evaluate the efficacy and safety of Video-Assisted-Thoracoscopic Surgery (VATS) in left-to-right Nuss procedure for

the treatment of pectus excavatum in Viet-Duc Hospital.

Subjects and Study Methods

Study subjects: From February to August 2018, 111 patients with pectus excavatum underwent VATS Nuss procedure at Department of Cardiovascular-Thoracic Surgery, Viet-Duc Hospital.

Patients' selection: All patients with pectus excavatum had indications for surgery, irrespective of age and gender. Surgical protocol was approved by Medical Board of the hospital (ethical approval code: IRB-VN01001) and was consented by patients' families. Medical record must include all required information for the study. Patients with sternal cleft, Poland's syndrome, pectus carinatum, additional complex deformities were excluded from our study.

The severity of pectus excavatum: Patient was in supine position, a ruler was placed across the lowest point of the chest, the distance from the deepest point to the ruler was measured (d). The disease severity was classified based on "d" as follow: d ≤ 1cm: mild; 1.5 ≤ d ≤ 2.5cm: moderate; and d ≥ 3cm: severe. The serious case has the sternum very close to the spine [4].

Indications for surgery: Pectus excavatum causing compression on the heart and the lung (dyspnoea, chest pain, cardiovascular dysfunction); pectus excavatum affecting the patients cosmetically or psychologically (low self-esteem, shy, embarrassment); Haller index > 3, 25...[6] (Figure 1).

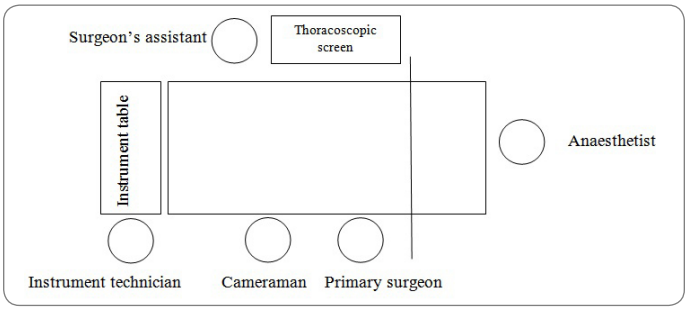

Figure 1: Arrangement of surgical team

Surgical protocol for VATS left-to-right Nuss procedure in Viet-Duc Hospital: Anaesthesia and positioning the patient: Patient was placed in supine position with two arms perpendicular to the body. General anaesthesia was performed with single lumen endotracheal tube; a pillow was placed transversally under the back of the patient to raise the chest; epidural analgesia was used to reduce postoperative pain.

Nuss procedure innovation: Draw and mark important surgical landmarks: planned skin incisions to place the pectus bar (in two mid-axillary lines, one inter-costal space higher or lower than the planned position of the bar); planned positions for trocars placement (left anterior axillary line, two intercostal spaces below the planned position of the bar). The surgeon measured the required size and then appropriately bent the pectus bar (Figure 2).

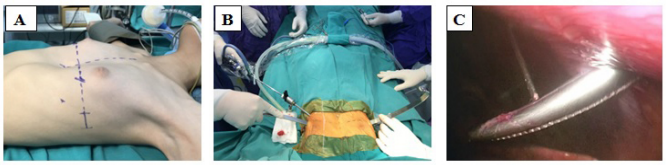

Figure 2: A) Surgical process, Draw and mark important surgical landmarks. B) Place the Pectus bar and raise the sternum anteriorly as expected under the control of left thoracoscopy. C) The left tip of the Pectus bar was fixed by a steel stitch under the control of left thoracoscopy.

One 5 mm-trocar was placed at the marked point at the left thoracic wall, low-pressure CO_2 (5 mmHg) was insufflated into the pleural space to deflate the lungs, the camera was then introduced to the left thoracic cavity for observation. The skin was incised at the marked points on both side of the thoracic cage, blunted Pince was used to dissect the subcutaneous tissue and thoracic muscle to create a wide-enough cavity from the skin incisions to the highest edge of the concaved chest for bar placement. Pince or Crawford clamp was employed to pinch the left pleural membrane at the highest edge of the sunken chest in left chest wall, then gradually moved along the inner side of anterior chest wall towards anterior mediastinum at the deepest point of the concavity. The pericardium was gradually dissected from the back of the sternum to create a tunnel to the right pleural space. The "introducer bar" was introduced through the created tunnel from the left pleural space, through anterior mediastinum, to the right pleural space and penetrated the right chest wall at the highest edge of the concavity, and then exited at the right skin incision point. Tunnel creation and the introduction of the introducer bar were controlled by left-thoracic thoracoscopy. One stitch was used to tie the pectus bar with the introducer bar, and the combination was fixed to the right chest wall. The introducer bar was then removed, followed by the introduction of the pectus bar from the right to the left thorax through the mediastinum under the observation of thoracoscopic camera. The concaved side of the pectus bar was always oriented posteriorly during this process. The pectus bar was rotated 180 degrees superiorly, both tips of the pectus bar were gently moved to raise the sternum anteriorly as expected. A purse-string suture using a steel stitch through the rib was performed and then fixed to the pectus bar through a hole at the left tip of the bar under thoracoscopic camera. The right tip was fixed to the chest muscles using a Vicryl no. 0 stitch. The anaesthetist used the bag-valve mask to inflate the lung through the endotracheal tube, as well as to remove the air. All trocars were removed, the skin incisions were closed, and no pleural drain was placed.

Efficacy and safety in left-to-right Nuss procedure for the treatment of pectus excavatum

Efficacy: better access and observation of the heart so cardiac injuries during surgical manipulations can be avoided; the process to create a tunnel from left pleural space to the right pleural space through the mediastinum is easier, more quick, convenient, and

precise.

Safety: no cardiac, pulmonary, vascular, or diaphragmatic injuries occurred during surgery.

Data analysis: Data were presented as mean ± SD for continuous variables, and as number and percentages for discrete variables. All data analyses were performed using SPSS version 16.0.

Results

General information of study subjects: Our study included 111 patients with pectus excavatum underwent VATS left-to-right Nuss procedure, among which 70 patients had moderate (63.06%); 40 patients had severe (36.04%); and 1 patient had serious pectus excavatum (0.9%) Table 1.

Table 1: Surgical parameters

Parameters		Results
Operation time (minutes)		48 ± 18 (30–100)
Post-operative length of stay (days)		4.93 ± 1.12 (3–11)
Number of bars	1 bar (n)	105 (94.59%)
	2 bars (n)	6 (5.41%)
Intra-operative chest drainage(%)		0%
Epidural analgesia (%)		100%
Bar fixation (%)	Steel+Vicryl stitch	100%

Nuss procedure innovation results: All patients were operated on successfully; 100% of cases were performed with left VATS only; 100% of cases had the bar fixed by a steel stitch on the left side and a Vicryl number 0 stitch on the right side. The average operation time was 48 ± 18 minutes, minimum 30 mins and maximum 100 mins. Rates of completely resolved and significantly improved-sunken chest were 64.86% and 35,14%, respectively. Almost all patients had dry and nice surgical wound (96.4%) Table 2.

Table 2: Intra- and post-operative complications.

Complications		n	%
Intraoperative complications	Bleeding, cardiac-respiratory injuries	0	0
Post-operative complications	Surgical wound infection	1	0.90
	Pneumothorax	3	2.70
	Haemothorax	0	0
	Pain	2	1.80
	Pneumonia	1	0.90
	Atelectasis	1	0.90
	Bar displacement	2	1.80
	Death	0	0
	Cardiac arrhythmia	0	0

No death or serious surgical complications occurred. Two patients (1.8%) suffered from mild pectus bar displacement without requiring re-operation, 3 patients (2.7%) had post-operative pneumothorax due to incomplete deairing during surgery. Among these patients, one severe case required drainage which was removed after two days. There was one case of pneumonia (0.9%) and 1 case of mild atelectasis, both were treated medically. The average length of stay after the surgery was 4.93 ± 1.12 days (range: 3–11 days). One patient suffered from infection of surgical wound that required antibiotics treatment and was discharged on postoperative day 11.

Discussion

Pectus excavatum (funnel chest) is the most common chest deformity which affects the patients both cosmetically and psychologically. Severely concaved chest also affects cardio-pulmonary function due to compression [1]. Therefore, patients need to be operated on to improve the physical, metal, and cosmetic aspects of their lives. Due to the increasing awareness and knowledge of both patients and their parents, the treatment of pectus excavatum has received many attentions as well as advancements. Discussions about surgical options for pectus excavatum now focus on the following aspects: Nuss procedure with or without VATS; left, right or both-side-VATS; with or without CO_2 insufflation; with or without raising the sternum; optimal analgesia, etc. with the aim to make the procedure convenient, safe, effective, minimize surgical complications, and bring satisfaction to the patients [7,8]. The application of VATS in Nuss procedure for the treatment of pectus excavatum has been accepted worldwide. Many studies and reports have demonstrated the benefits of VATS in making Nuss procedure more convenient, safer, with less complications and severe adverse-events, especially in patients with severe and complex funnel chest and those with a history of thoracic surgery [9]. We only performed left-side VATS, with one 5 mm-trocar placed in the anterior axillary line, two intercostal space below the intended skin incision to place the bar (usually at the 6th–7th intercostal space). We used 0-degree optic, low-pressure (5 mmHg) CO_2 insufflation to fill the artificial pleural space with air, and to deflate the lung to create surgical space without raising the sternum. With this technique, we realized that the surgical field was wide enough, we could entirely observe the pleural space, left lung, vessels, heart, pericardium, mediastinum, and diaphragm so we could avoid serious complications. By placing the camera in the anterior axillary line for left thoracic observation, we could control all the manipulations to create the tunnel from left pleural space through mediastinum to right pleural space [10]. Putting the camera through this tunnel, we could observe the right lung and avoid sticking the right lung to guide bar and implant bar. Some authors support the placement of a trocar in the mid-axillary line [7,11]. However, we realized that if we place the trocar in the mid-axillary line, our visual would be obstructed by the heart, lung, diaphragm, especially in severely and asymmetrically depressed cases. We agree with Hendrickson and Palmer that left thoracoscopy has more benefits than right thoracoscopy in terms of reducing risk of cardiac trauma [12,13]. In almost all cases, the heart is deviated to the left pleural space so left thoracoscopy offers a more convenient observation and can avoid injuring the heart. In right thoracoscopy, on the other hand, the surgeon has

no prediction about the heart and diaphragm in left pleural space due to the obstruction by the sunken sternum. Through our study, we believe that left thoracoscopy and left thoracic approach have many advantages, such as: better access and observation of the heart so cardiac injuries during surgical manipulations can be avoided; the heart and the sternum form an acute angle points towards left thorax so the process to create a tunnel from left pleural space to the right pleural space through the mediastinum is easier. Furthermore, the majority of surgeons are right-handed and the right hand is used for surgical manipulations while the left hand is used to hold the camera, therefore, the surgeons may feel confident, and perform the surgery more quickly, conveniently, and precisely when approaching from the right thorax of the patient. In our study, no cardiac, pulmonary, vascular, or diaphragmatic injuries occurred during surgery. No patients suffered from cardiac arrhythmia during and after the operation. Pectus bar fixation: the bar can be fixed by splint, or steel stitch. In our study, all pectus bars were fixed by steel and vicryl number 0 stitches. The left tip was fixed by purse-string suturing around the rib and then tie to the pectus bar through a hole at the tip of the bar, all of which were performed under the control of left thoracoscopy. The right tip was fixed by suturing a vicryl no. 0 stitch to the chest muscle. Thoracoscopy helps to suture better, safer, fix the bar more securely to avoid bar displacement. This fixation technique is effective and reduces operation time, as well as treatment expenses. Many authors fix the bar by splint, though this technique provides a secured fixation, it costs more, and the area of skin contact is bigger, which can lead to skin necrosis [14,15]. In our study, the mean operation time was 48 ± 18 minutes, minimum 30 mins and maximum 100 mins. Only two patients suffered from mild bar displacement that did not require reoperation. According to Lam Van Nut [16], the average operation time was 91 ± 31 minutes; 0.9% bar displacement requiring reoperation; there was no difference in rate of bar displacement with splint or steel stitch-fixation. According to Vu Huu Vinh [17], the bridge fixation technique is a satisfactory technique to manage pectus excavatum, it takes less time to perform, does not lead to bar displacement. We did not place a pleural drain since we realized that all surgical manipulations in the thorax had been well-controlled under thoracoscopic camera observation, pleural space de-airing was performed by inflating the lung through the endotracheal tube and through thoracoscopic trocars. Post-operative chest X-ray was performed on every patient and there was no haemothorax, 3 patients suffered from pneumothorax among which one severe case required pleural drainage that lasted for 2 days. Intra- and post-operative analgesia: we added epidural analgesia for all cases and maintained it for 3–4 days after surgery. Therefore, almost all patients in our study did not suffer from post-operative pain. Epidural analgesia helps to eliminate post-operative pain, avoid limitations in respiratory function as well as post-operative fear, and contributes to the satisfaction and comforts of the patients after the surgery.

Conclusion

Surgical treatment for pectus excavatum by Nuss procedure with the assistance of left thoracoscopy and left-thoracic access was demonstrated efficacy, safety, convenience, and it has high success rate with low complication rate.

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Competing Interest

None declared by the author.

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