Single-centre Indian case series using X or cross bar for Nuss procedure in pectus excavatum

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Abstract

The modified Nuss procedure using two bars lying parallel or non-intersecting is used to correct pectus excavatum with varying degrees of patient satisfaction. This bar placement has its limitation for certain pectus excavatum morphology where the deformity is deep and focal or located below the subxiphoid. We have altered our bar placement so that bars intersect in an X or cross manner for such pectus morphology. We describe the X or cross bar placement and its specific indications based on morphology in a series of five patients from February 2019 until December 2019 with symmetrical focal deformity along the xiphisternum and asymmetric deformity below the xiphoid. The operating time varied from 90 to 120 min. There was no significant postoperative morbidity. They are on follow-up with period ranging from 4 to 15 months from the day of surgery. Early results show the X or cross bar Nuss procedure can be safely performed to achieve a desired long-term morphological correction of symmetric deep focal xiphisternal defects or asymmetric deformity below the xiphoid.

Keywords X bar · Cross bar · Nuss procedure · Pectus excavatum

Introduction

Pectus excavatum, also known as funnel chest, is one of the most common developmental disorders of the chest wall, comprising about 80% of the deformity. The deformity results in a symmetrical or asymmetrical depression of the sternum and adjacent rib cage, with the xiphisternum depression appearing most severe for lower sternal depression. The incidence and prevalence of pectus excavatum in India are not known; however, we are seeing cases across all groups in children, teenagers and adults coming to our clinic, seeking information and treatment after browsing the internet. Worldwide, the incidence reported is 1 in 400 to 1000 live births, with male predominance occurring 4 to 5 times, and tends to be sporadic or may be associated with connective tissue disorders, neuromuscular disease and a family history

[1]. Most of our patients in India seek consultation for cosmesis, psychological disturbances and nonspecific chest pain. They usually do not have symptomatic respiratory or cardiac dysfunction during normal sedentary activities. We have been performing a rather modified version of the Nuss procedure for pectus excavatum in India since 2012 using video-endoscope, pectus tunneloscopy along with various fixation devices and our described sutureless moon bridge system for a stable bar [2, 3]. A few reports on Nuss procedure for pectus excavatum from India can be traced back to Puri et al. who reported 2 cases in pediatric age group in 2003 [4]. In view of the relatively normal cardio-respiratory function, the main concern in people with this deformity is about a good cosmetic correction, which will enable them to do outdoor activities, as well as alleviate their psychological problems and thus improve the quality of their life. We describe the X or cross bar technique of Nuss procedure in symmetric pectus excavatum with focal deformity localised to the xiphisternum, which correspond to Park morphological classification of symmetrical type 1A [5] (Fig. 1), and in cases of asymmetric excavatum located below the level of xiphoid process. The X or cross bar has been reported earlier in literature, but its specific indications have not been clearly described.

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Fig. 1 Images of type 1A symmetric pectus excavatum on **a** computerised tomographic scan chest. **b** Chest X-ray lateral view (arrow). **c** Morphology of deep focal symmetric xiphisternal defect (arrow)

Case series

We have been performing a modified version of the Nuss procedure for pectus excavatum since 2012, using single bar in young children, and 2 or more bars in adolescent, teenager or adults. However, we have modified our selection criteria since 2014 and prefer to wait until adolescence in children, in view of the unpredictable effect of growth spurt on the pectus deformity. From this period on, it is our practice to use 2 bars in all cases for pectus excavatum to achieve a long-term stable correction. Our modification, besides the already described Park crane elevation technique and pectoscopy [6], involved the use of a 5-mm 0° rigid thoracoscope. This aided the retrosternal tunnel creation and visualisation of tunnel, known as pectus tunneloscopy, along with our sutureless fixation of bar using moon bridge bar stabilisation technique [2, 3]. It was observed that despite the use of parallel double bar, cases with deep focal symmetrical deformity in the xiphisternal area (Park classification symmetrical type 1A) were likely to have residual minimal depression at that site during follow-up

period. The obvious cause was that we were elevating the depressed target site inefficiently with a single bar, as the 2nd parallel bar was placed in the preceding higher intercostals space away from target. This resulted in an inefficient use of the 2nd bar as the chest sunk over time, due to bar elevation at a point away from the target depression. The X or cross placement of 2 bars at this focal depressed target site made it possible to efficiently correct this deep focal xiphisternal depression long term.

Patients We describe 5 cases of pectus excavatum, having symmetrical deep focal depression in the xiphisternal area and asymmetric deformity below the xiphoid level, repaired using the X or cross bar Nuss procedure from February 2019 to December 2019. All patients had a routine chest X-ray posteroanterior view and the lateral view showing the focal xiphisternal depression and also a 2D echocardiogram. Initially a computerised tomographic scan of chest involving radiation exposure and pulmonary function test was done in all cases, but we now restrict it to patients for insurance

purpose to measure Hallers index, and those with asymmetric deformity for a 3-dimensional chest wall reconstruction to look for target areas, or in asthmatic patients for preoperative stabilisation [7].

X bar or cross bar Nuss technique The modified Nuss procedure was performed under general anesthesia with preoperative thoracic epidural placement for postoperative analgesia. The patients were positioned supine with arms abducted by the side and the Rultract retractor or Thomson retractor attached to the left side of the operating table. The target site, where the bars should lie, is the site of maximal depression and was marked on the skin surface. A sternal lift using the crane technique described by Park et al. was followed using sternal wire passed through the cortex of sternum at 2 levels for elevation of depression using Thomson retractor [6] (Fig. 2). The retrosternal tunnel was created using two mid-axillary, approximately 4 cm, skin incisions on either side under 5-mm 0° rigid thoracoscopic guidance for the bars to cross the sternum at the target site in a cross fashion (Fig. 2). Pectus tunneloscopy, described by the author, was performed to look for any injury during retrosternal tunnel creation, as well as passing the bar in the tunnel under vision [2]. Symmetrical bars were then modelled on table and placed in the retrosternal space in X or cross fashion. On achieving desired chest morphology after remodelling and reinsertion of the bars, it was stabilised using a sutureless moon bridge

bar stabilisation technique using plates, clips and nuts described by the author [3] (Fig. 2). The mid-axillary wounds were closed over a flat drain placed in chest wall subcutaneously and in the pleural cavity. We extended the use of X or cross bar to a case of right-sided asymmetric pectus excavatum, located well below the xiphoid level, by placing an asymmetric X or cross bar below the subxiphoid level (Fig. 3). The asymmetric X or cross bar was placed more obliquely, with intersection of X bar located towards the side of deformity, away from midline, thus allowing for maximal area of chest wall elevation in the subxiphoid area (Fig. 3). Following this, all patients were extubated on table and shifted to the postoperative intensive care unit for overnight observation. Postoperatively, chest X-ray was done routinely to look for pneumothorax, baseline position of bar, plates, clip and nuts or pleural collection (Figs. 2 and 3). Postoperative pain control, which is a very important component in patient recovery, was achieved using epidural analgesia for about 3 to 4 days, along with oral analgesics. Patients were allowed orally when fully awake and conscious, after about 4 h of extubation. On postoperative day 1, patients were shifted to the ward and mobilised out of bed with minimal support. The flat drains were removed when the colour was serous, and volume less than 100 ml, with a chest X-ray showing expanded lung. During hospital stay, intravenous antibiotics were given for a period of 3 days and converted to oral antibiotics till discharge. With the use of moon bridge bar stabilisation

Fig. 2 Images showing X or cross bar repair of deep focal symmetric xiphisternal defect. **a** Sternal wire lifting of deformity. **b** Mid-axillary skin incision for passing 5-mm 0° rigid thoracoscope and the expected lie of

the X or cross bar. **c** Morphology of corrected pectus after X or cross bar placement. **d** Symmetric X or cross bar seen on chest X-ray PA and lateral views

Fig. 3 Images showing X or cross bar for asymmetric pectus excavatum lying below the xiphoid. **a, b** CT chest showing asymmetric deformity in the right costal area. **c** Morphology of right asymmetric costal deformity. **d, e** Asymmetric X or cross bar seen on chest X-ray PA view and lateral view. **f** Morphology of chest wall following repair

technique, the fear of bar displacement is negligible and the patients were advised to lie on their back for about 4 weeks, following which they could gradually turn on the sides. All patients were advised against contact sport, which can create direct impact on the bar, until the bar is removed, which is usually after 36 months.

Results of case series

Table 1 shows the characteristics of five patients with age group varying from 15 to 32 years and a male predominance of 4:1. The length of the bar varied from 12 to 14 inch. and 2 bars were used in each case to form an X or cross bar. The operative time varied from 90 to 120 min, as the aim was to get a near perfect symmetrical chest morphological correction, which required multiple remodelling and reinsertion of bar. The

blood loss during the procedure was minimal, with no requirement for blood transfusion. The flat drains placed in the subcutaneous and pleural space were removed on the postoperative days 3 and 4 when drainage was less than 100 ml, serous in nature with chest X-ray showing expanded lungs. The postoperative hospital discharge day, with the day of surgery taken as zero day, was 4 days, except in 2 cases, where the discharge was delayed by a day due to opioid analgesia-induced nausea and vomiting and elective discharge as per patient's convenience for travel. There was no incidence of wound infection. During an online follow-up ranging from 5 to 15 months, we have not had any of our patients complaining of bar displacement or other complications. Bar removal is planned at the end of 36 months, which will give us the final results of the use of X or cross bar placement in Nuss procedure. Short-term results have been very encouraging in terms of patient satisfaction and complications.

Table 1 Showing patient characteristics and perioperative course

No	Age/sex	Drain removal day	Bar size (inch.)	Postop hospital discharge (days)	Complications
1	32/M	4	12	4	Nil
2	25/M	3	14	4	Nil
3	15/M	3	13	4	Nil
4	28/F	4	12	5	Opioid-induced nausea
5	32/M	3	13	5	Nil

Discussion

The most common indications for correction of pectus excavatum are cosmesis and alleviation of the psychological low self-image and esteem associated with it, thus improving their quality of life. There are also not visible, but measured, parameters, which show improvement in cardio-respiratory functions, seen with physical activities, and as measured by increased maximal oxygen consumption during cardio-pulmonary exercise testing—an indicator of improved maximum voluntary ventilation and minute ventilation, along with an increased cardiac stroke volume [8]. A successful and sustained long-term morphological repair is critical to patients' satisfaction and reported improvement in cardio-pulmonary function [9]. The use of the X or cross bar has already been reported by Park and Pilegaard, but they did not specifically describe the type of pectus deformity which would benefit the most, though Pilegaard referred to short excavations and Park reported one case [10, 11]. We found that in our cases of pectus deformities, which were deep focal type and usually limited to the lower sternum or xiphisternal areas, with a small target area, they were best elevated using the X or cross bar. This is the typical deformity described in Park morphological classification as type 1A symmetrical deformity [5]. The X or cross bar placement enabled us to effectively use the force, and combined strength of 2 bars, to effectively lift the focal target area of depression (Fig. 2d). This is unlike using two parallel bars, where the lower bar lifts the focal target area less effectively, due to the rigid sternum, and the upper bar lifting the sternum away from the focal target area, and resulting in apparent good morphological correction on table and short term. However, as bar sinks during the follow-up period, the suboptimal correction becomes apparent due to weaker force of a parallel single bar at target area (Fig. 4). The X or cross bar meeting point can also be modified and shifted away from midline, by placing the bars more obliquely, to allow lifting of asymmetric deformities located well below the xiphisternum (Fig. 3d, e). Using this modification, we are able to effectively correct asymmetric deformity located between the subxiphoid and costal cartilage. The stable and un-displaceable placement of the bar in the desired angulation is very critical for sustained morphological correction to be achieved in the long term. In recent years, since

2013, we are using a sutureless stabilisation of the bars, using the clip, nut and 1/3 tubular plate system, which we described earlier as moon bridge bar stabilisation technique [3]. This stabilisation technique provides a stable un-displaceable bar configuration in the desired angulation of the cross bar. Even in those cases where suture or wire stabilisation of bar is done, the effect of two flat bars lying over each other reduces the chances of bar rotation or displacement, though angulation may change, resulting in a not so desired morphologic correction, which will be a drawback for such complex morphology correction. The bar displacement rate, described in the literature, with the use of stabilisers and multiple wire or suture fixation to the ribs ranges from 1 to 5%, which contrasts to the original Nuss procedure reporting 15% [6, 12–14]. We did not see any bar displacement-related complications in our series on the X or cross bar technique. The operating time

Fig. 4 Follow-up chest X-ray lateral view showing inefficient lifting of lower xiphisternal area (marked x) with use of 2 parallel bars

reported in literature varies widely, with some reporting median time of as little as 30 min, but the majority of less than 60 min [11]. However, in our series of 5 cross bar Nuss procedures, the aim was to get a symmetrical morphological correction of the pectus deformity and this involved remodelling the bar and reinserting the bar multiple times, until we achieved a satisfactory morphological cosmetic correction. With the aim of achieving a good cosmesis, which our patients are most concerned about, we believe operating time should not be a consideration. In the present times, due to lack of uniform morphological classification of the pectus deformity and its rarity, it will be difficult to specifically indicate the use of X or cross bar more widely, though we strongly believe that its use is not limited to the conditions we described. Surgeons, with their innovative ideas, will make use of the X or cross bar by placing it in a symmetric, asymmetric or oblique disposition, based on the morphology of pectus. In our study, the short-term results are very encouraging.

Conclusions

The X or cross placement of 2 bars helps in lifting the target depression site efficiently by increasing the strength and stability of elevating force at target site, which previously was under-corrected because of the 2 parallel bars lifting at different levels. Asymmetric deformity below the xiphoid level can also be effectively corrected by asymmetric X or cross bar placed obliquely.

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Compliance with ethical standards

Conflict of interest The author declares that there is no conflict of interest.

Ethics approval Not required

Informed consent Consent taken

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