The Sternal Turn Over Procedure with Preservation of the Internal Mammary Vessel and Rectus Abdominis Muscle Pedicles for the Repair of Severe Pectus Excavatum

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Abstract : **Pectus excavatum or funnel chest is one of the most common congenital chest wall deformities. Surgical correction should be considered for all patients with moderate to severe deformities because of the significant cosmetic and psychological improvement, subjective increase in exercise tolerance, documented changes in the cardiac and respiratory status, and prevention the development of scoliosis after surgical intervention in these patients.**

The sternal turn over procedure with preserved internal mammary vessels and rectus abdominis muscle pedicles for the corrective repair of severe pectus excavatum, involves resection of the deformed thoracic wall, sternum and ribs, preserving an attachment of the rectus abdominis muscle, and a vascular pedicle of the internal mammary vessel. A short segment resection above the ipsilateralcostal cartilage is mandatory to allow reposition of the vascular pedicle onto the presternal surface after turn over of the sternum. Multiple corrective osteotomy and costoplasty must be completed before refixing the sternum and ribs.

The modified sternal turn over procedure restores the sternal blood supply and should be applied to the severe form of pectus excavatum which needs extensive and multiple bony resection. The procedure has been applied to a boy and a girl aged 5 years. At a three year follow up, the results obtained are excellent.

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เรื่องย่อ : **การผ่าตัดแก้ไขโรคหน้าอกบุ๋มอย่างมากด้วยวิธีพลิกกลับกระดูกสันอกโดยไม่ตัดกล้ามเนื้อเร็คตัสแอบโดมินิสและเส้นเลือดอินเทอนัลแมมมารี่หนึ่งคู่ที่เข้ากระดูกสันอก**

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สารศิริราช 2545; 54: 19-26.

ภาวะหน้าอกบุ๋มเป็นความผิดปกติที่เป็นมาแต่กำเนิดของโครงสร้างผนังทรวงอกที่พบบ่อยที่สุด ในรายที่มีความผิดรูปขนาดปานกลางถึงรุนแรงมาก การผ่าตัดแก้ไขทำให้รูปทรงของผนังทรวงอกดูดีขึ้น ขณะเดียวกันทำให้ระบบการทำงานของปอดและหัวใจดีขึ้น ช่วยเพิ่มความสามารถในการออกกำลังกายและป้องกันการเกิดกระดูกหลังคดตามมาได้

การผ่าตัดโดยวิธีพลิกกลับกระดูกสันอกโดยไม่ตัดกล้ามเนื้อเร็คตัสแอบโดมินิสและเส้นเลือดอินเทอนัลแมมมารี่หนึ่งคู่ที่เข้ากระดูกสันอก ทำโดยตัดกระดูกสันอกส่วนบนและกระดูกซี่โครงติดกันที่ผิดรูป โดยคงไว้ส่วนของกล้ามเนื้อเร็คตัสแอบโดมินิสที่ยึดติดกับส่วนล่างของกระดูกสันอกและกระดูกซี่โครงอ่อนบริเวณขายโครง และไม่ตัดเส้นเลือดอินเทอนัลแมมมารี่หนึ่งคู่ทางด้านบนที่เข้ากระดูกสันอกนั้น ตัดบางส่วนของกระดูกซี่โครงอ่อนที่อยู่ถัดขึ้นไปเพื่อเป็นทางให้เส้นเลือดนี้ทอดข้ามกระดูกกลางอกส่วนบนไปยังด้านตรงข้ามโดยไม่ตึงเมื่อมีการผลิกกลับของกระดูกสันอก ร่วมกับทำการผ่าตัดแก้ไขกระดูกสันอกและกระดูกซี่โครงบางส่วนเพื่อจัดรูปทรงของกระดูกให้เหมาะสมก่อนยึดกระดูกกลับคืน

การประยุกต์วิธีการผ่าตัดผลิกกลับกระดูกสันอกนี้ ทำให้มีเลือดเข้าไปเลี้ยงกระดูกสันอกทั้งจากด้านบนและด้านล่าง การผ่าตัดวิธีนี้น่าจะนำมาใช้ในผู้ป่วยที่มีการผิดรูปของกระดูกหน้าอกอย่างมากและต้องมีการตัดเพื่อจัดรูปกระดูกหลายแห่ง การผ่าตัดนี้ได้นำมาใช้ในเด็กอายุ 5 ขวบ เป็นชาย 1 คนและหญิง 1 คน จากการติดตามผลการผ่าตัดเป็นเวลา 3 ปี พบว่าได้ผลดีมาก

Pectus excavatum (PE) or funnel chest is the most common congenital deformity of the chest wall and one third of the patients has a family history. The deformity consists of a posterior depression of the sternum and the lower costal cartilages. The first and second ribs and manubrium are usually normal, whereas the lower costal cartilage and sternum are depressed. Most patients with pectus excavatum usually present at birth or within the first year of life. Pectus excavatum occur in more than 1 in 1,000 births and becomes more apparent during the period of rapid skeletal growth in early adolescence.[1] Deep inspiration commonly accentuates the pectus depression. Occasional patients experience chronic bronchitis, asthma, or bronchiectasis during adolescence. Spontaneous regression of pectus excavatum rarely occurs.[1] The effect of pectus excavatum on longevity is unclear; however, severe pectus deformities are rarely found in autopsies on persons over 60 years old.[1] The etiology of pectus excavatum is unknown but overgrowth of the costal cartilages, aseptic osteonecrosis and an inflammatory process have been considered to be the causes of the deformities with an unexplained mechanism.[2] The deformities may worsen at adolescence and scoliosis has been identified in more than 20% of

pectus excavatum patients. There are two type of pectus excavatum. Symmetrical deformity is more common and is often seen in children but asymmetrical or unilateral deep excavation is found increasingly in older children. The right side is often more depressed than the left, and the sternum may be rotated as well. Pulmonary function at rest may be borderline or within normal limits but may have a decreased maximum breathing capacity. Many of the patients frequently have a systolic murmur at the left parasternal area possibly from partial pulmonary outflow tract compression and cardiac output is normal at rest but decreases during exercise.[3] For the moderate to severe form of pectus excavatum, surgical correction should be offered because of the significant cosmetic and psychological improvement, subjective increase in exercise tolerance, documented changes in the cardiac and respiratory status, and prevention of the development of scoliosis after surgical intervention in the patients.

Since, the first surgical corrections of pectus excavatum, reported by Meyer in 1911, there are three common surgical procedures. Bilateral costal resection with or without sternal bars or Modified Ravitch's operation, firstly reported by Ravitch in 1949, is the most popular procedure for pectus repair, but there is occasionally major recurrence of the deformity and it is difficult to predict which patients will have a major recurrence. The other major complication is migration of the metal struts or retrosternal bars that are used for temporary internal fixation.[4,5,6,7] Recently, a Marlex mesh and Dacron vascular graft has been used to support the sternum instead of different metallic splints. They are strong and hold well until the chest wall solidifies, are resistant to infection and it may be left in place permanently.[8,9,10] Another method of pectus repair, mainly for a good cosmetic result, involves the implantation of a prosthesis such as a silastic mold into the subcutaneous space to fill the deformity but this method does nothing to correct the anomaly of the bony chest wall, improve respiratory mechanics, or relieve pressure on the heart. Extrusion of the prosthesis is a major complication of this surgical technique. This technique should be restricted to cases of moderate excavatum anomaly in late teenage patients and to adults without cardiorespiratory symptoms. The "sternal turn over" was first proposed by Judets (1954) and Jung (1956) in the French literature but was popularized by Wada and colleagues in 1970. Since then, there are some modifications of the procedure including preservation of the internal mammary vessels by wide dissection or reimplantation of the internal mammary artery using a microsurgical technique[11,12,13,14] or leaving the rectus abdominis muscle pedicle intact with the turn over sternum.[15,16,17] The major complications of these techniques are osteonecrosis and fistula formation which develop more often in patients over 15 year of age.[2] To eliminate these complications by improving blood supply to the sternum can be done by preserving the internal mammary vessel pedicles or rectus abdominis pedicles. Both modifications take about fifteen to thirty minutes longer than the conventional sternal turn over operation. To maximize the immediate blood supply to the sternal turn over, we combined both modification procedures to the conventional sternal turn over operation to patients with severe deformities who needed multiple corrective osteotomy and chondrotomy. Our modified sternal turn over technique was applied to two patients aged five years old. The first patient was a girl and the second patient was a boy who had had a previous right thoracotomy and upper lobectomy for an infected lung cyst at two years. (Figure 5,6)

Surgical technique:

The patient lies down on the table. With the patient under endotracheal anesthesia, a bilateral sub mammary incision was made between the anterior axillary line. The pectoralis muscles were detached on both sides of the sternum, then stripped and retracted laterally, thereupon, all involved sternum and cartilages were exposed. The anterior rectus sheaths were also stripped and retracted downward to expose the upper one third of the rectus abdominis muscles. A short segment about one centimeter, of the second left costal cartilage over the internal mammary vessels was resected.The second intercostal muscle, ribs or costal cartilages were transected bilaterally at the costal arches along the margin of the deformity in a tangential direction. The sternum just below the second costal cartilage was transected using gigli saw. The left internal mammary vessels were kept

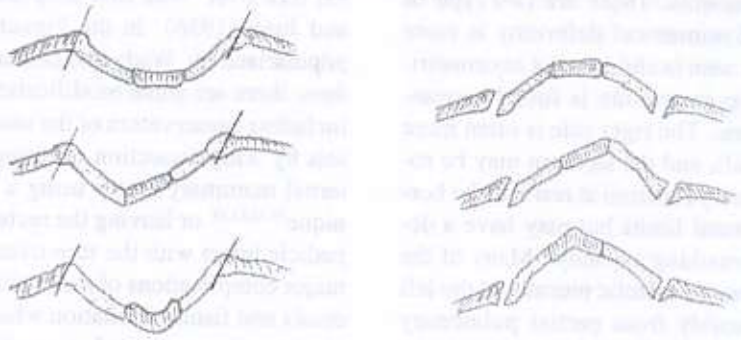


Figure 1. The costal cartilages were transected in tangential direction and the sternal complex was turn over 180 degree.

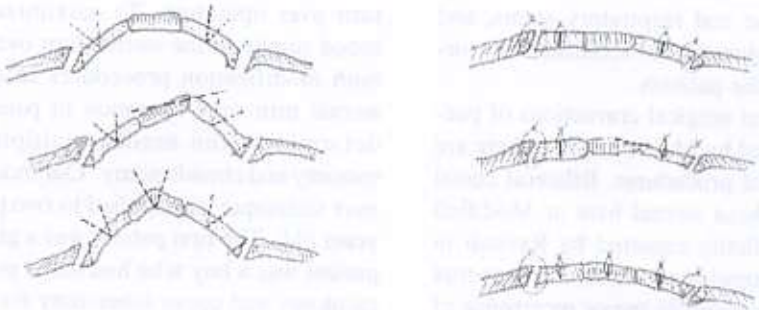


Figure 2. Multiple corrective osteotomy, chondroplasty and partial excision of the sternum was performed after turn over the sternum.

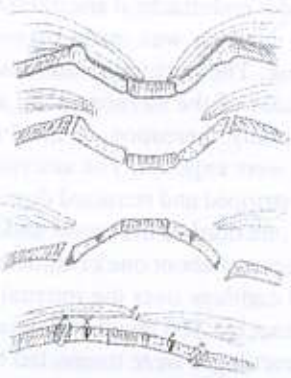


Figure 3. The cross-section showed relationship between the pectoralis major muscles and the sternum before and after sternal turn-over operation.



Figure 4. The diagram showed the transectional line of the sternum, ribs and pedicles of the internal mammary vessels and rectus abdominis muscles after sternal turn over.

but the right internal mammary vessel was doubly ligated and divided. All the deformed sternum and ribs were lifted up to expose the posterior rectus sheaths and then only the sheaths close to the sternal complex were transected, leaving the rectus muscle intact with the sternum inferiorly and the internal mammary pedicle superiorly. The sternal complex was turned over 180 degree, keeping the left internal mammary vessels that lie over the manubrium, careful not to injure both vascular pedicles. (Figure 4) The deformed sternum and costal cartilages were corrected by multiple wedged excision or partial resection and are fixed with Proline 20 sutures. (Figure 1,2,3) Refixing of the sternum was completed using a stainless steel wire, suturing in a figure of eight fashion. A chest tube was placed in each pleural cavity. Both pectoralis major muscles were sutured together in the midline. A small vacuum drain was placed over the pectoralis muscles before closing the incision.

RESULTS

The patients recovered well from the operation without respiratory support or other complications. There was no paradoxical movement of the chest wall during respiration. The patients were discharged from the hospital on the 6 th postoperative day. Three year after surgery, a normal appearance of the chest contour was observed. (Figure 5,6)



Figure 5. Chest contour of the patients before surgery.

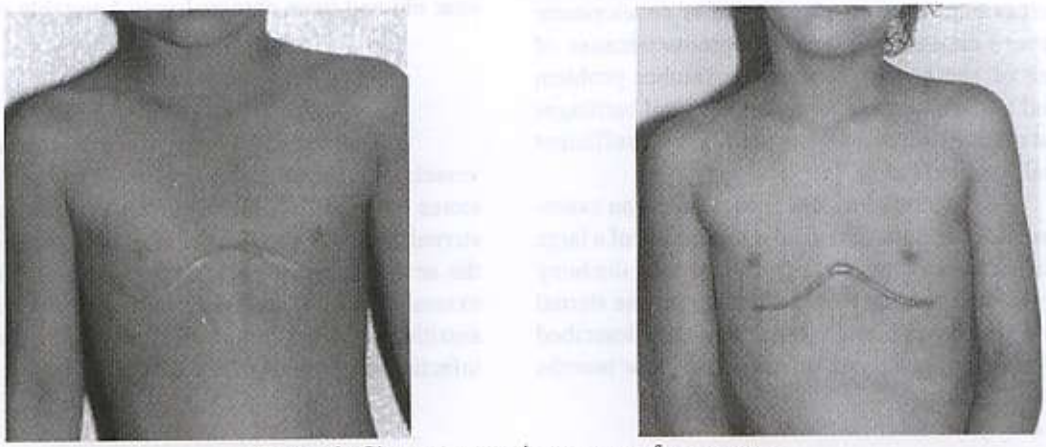


Figure 6. Chest contour three years after surgery.

DISCUSSION

Surgical reconstruction of the sternum and ribs in patients with pectus excavatum may relieve structural compression of the chest and allows normal growth of the thorax, and prevents pulmonary and cardiac dysfunction in teenagers and adults.[18] These methods may be classified into two types: sternal elevation and sternal turn over. The problem of pectus repair is which technique to choose and the maintenance of the repair. The early results of such repairs are usually satisfactory, with more than 90% of patients having good to excellent results mainly depending on the technique used but sometimes early recurrence may occur because of too early removal of the internal support.[18] Without any internal and external fixation, the sternal elevation procedures described by Ravitch had an significant incidence of recurrence caused by the retraction of soft tissues by which the sternum is held after the repair. Most of the surgeons currently favors some methods of postoperative sternal fixation to hold the mobilzed and elevated sternum in position during healing and to avoid recurrence of the sternum depression after the repair. The major complication of the technique is the migration of the metal struts or retrosternal bars that used for temporary internal fixation.[2,5,6] Although the importance of removing all deformed cartilages has been stressed for modified Ravitch's operation, recent research in animals has suggested abnormal development of the thoracic cage arises after resection of rib cartilages. Such extensive pectus excavatum operations, may cause development of severe cardiorespiratory symptoms because of failure of chest wall growth.[19,20] Another problem related to the extensive resection of costal cartilages is that of infection or necrosis because of insufficient sternal vascuarization.[18]

The sternal turn over procedure is an extensive surgical operation. It involves resection of a large portion of the sternum and ribs and refixing the bony complex after turning it over 180 degree. The sternal growth of conventional sternal turnover described by Wada may have been affected for a few months postoperatively; however, long-term follow-up of these patients shows persistent normal growth of the thorax with improved contour of the anterior chest wall.[15] The operation has afforded immediate excellent results and avoids the potential complications from temporary metal splints and struts. The major complications of these techniques are osteonecrosis and fistula formation that related to the lack of blood supply and infection to the sternum. To avoid this complication, additional procedures to improve the blood supply to the sternum should be done. Which special care during dissection, the preservation of one or both internal mamary vascular pedicles or reanastomosis of the internal thoracic artery and veins may assure the viability of the sternum and costal cartilages in the everted position. Previous reports have demonstrated postoperative examinations, such as bone biopsy, sternal puncture and indium chloride test, revealed definite signs of living tissue and angiogram revealed patency of the internal mammary arteries. This procedure results in minimal secondary deformity postoperatively and is indicated for adults as well as children.[12] Instead of free grafts, the turn over sternum with vascular attachment superiorly from one or both internal mammary pedicles and inferiorly from rectus abdominis pedicles may give an adequate blood supply for healing after the repair and may minimize the incidence of sternal necrosis, infection and chronic sinus formation aswell. We have performed the modified sternal turn over technique in a boy and a girl aged five year old and have obtained very favorable results.

CONCLUSION

The sternal turnover with internal mammary vessels and rectus abdominis muscles pedicles restores the blood supply better than the conventional sternal turnover procedure. It should be applied to the severe form of pectus excavatum which needs extensive bony resection or to the patient with malnutrition to avoid failure of chest wall growth and infection or necrosis of the sternum after the repair.

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