



Open repair of pectus deformity in the era of minimally invasive repair

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Pectus excavatum and carinatum are the most common chest wall deformities with wide spectrum of severity and morphologic diversity. Bostanci *et al.* described details of traditional open technique and its modifications including removal of costal cartilages, osteotomy and fixation materials, which is a good review for open technique and very informative. Minimally invasive repair (MIR) of chest wall deformities have been popular since Nuss *et al.* have introduced his innovative technique (1). The most important benefit of MIR is cosmetic aspect from small incisions. Moreover, MIR had better operative related outcomes; shorter operative time and less intraoperative blood loss compared to open technique (2). Recently, MIR with evolving additional refinement resulted in satisfactory outcomes with improved safety and complete correction of deformities. Minimally invasive method with technical modification including new devices; video-scope guidance; claw fixator; bridge device; crane technique, and other technical advancements including flare-buster and sandwich technique have been introduced (3-5). Simulating method was also introduced and could guide to localize bar insertion level and length of elevation in less experienced hands (6). In addition, several conservative treatment such as bracing device and vacuum bell device have been used for chest wall deformities with favorable outcomes (7,8).

Early correction may reduce psychological impairment and prevent undergrowth in young children (9-12). However, traditional open repair in children has a potential to induce acquired asphyxiating thoracic dystrophy (AATD), also known as acquired Jeune's syndrome, the most troublesome

late complication of traditional open repair. Younger age and excessive rib resection were the risk factors of AATD in the initial case series of Ravitch *et al.* (13). Suppression of cartilage growth leads to restrictive pulmonary function and impaired growth (14). Some studies with regard to treatment for AATD have been reported (15,16). However, experience had been limited and technical difficulty arising from extensive calcification and dense adhesion between sternum and vital organs was noted as well. Furthermore, true incidence of AATS has not been reported because most patients are not diagnosed if they had no symptoms. On the other hand, theoretically, MIR technique can minimize the development of AATD in the patients who are pre-school aged.

Despite of several advantages of MIR, data supported that MIR had more bar rotation and higher reoperation rate in the adult patient due to the stiffness and rigidity of the chest wall (17). Although there are some manageable complications including pneumothorax, seroma, etc., devastating disasters such as cardiac perforation, massive bleeding, and malignant arrhythmias have been reported occasionally. Catastrophic cardiac injuries, which might be under-reported, can occur during the insertion or removal of the pectus bar. Frequently, it led to mortality and severe neurologic sequelae (18). Prior cardiac surgery or severe pectus excavatum are highly associated with development of catastrophic complication intra- and postoperatively. Thoracoscopic guidance with lifting the sternum was used to prevent such events during the procedure. Notably, symmetric pectus excavatum can be easily corrected with MIR, but if the chest wall is stiff like an adult patient

the MIR alone may be difficult to perform a complete correction particularly in asymmetric type or complex deformity like as pectus arcuatum. In such cases, open repair technique including chondrotomy, osteotomy and various fixation methods can facilitate to obtain successful correction (19). Even, in cases of recurrent pectus excavatum after failed open repair or previous cardiac surgery, MIR achieved satisfactory outcomes with simple combination of open repair (16,20,21). Obviously, the terms, Hybrid Nuss or Modified Ravitch technique, imply the benefit and usefulness of combined surgical methods in nature, which can result in a complete correction of complex chest wall deformities.

The repair of chest wall deformity aims to restore functional impairment and achieve better cosmetic result. Cosmetic goal is highly subjective and hard to define depending on the severity of the disease, patient's needs and surgeon's ability. Therefore, the outcome of repair may vary depending on the surgeon's technique. Surgeon's ability to manipulate various surgical techniques is the key for the best outcome, which can expand surgical indications eventually. In my opinion, in the era of minimally invasive surgery, traditional open repair has an important role as an adjunctive treatment with MIR for difficult clinical settings; adults with severe complex chest wall deformity, particularly, underlying connective tissue disease, and stiff chest wall from prior thoracic or cardiac surgeries. Minimally invasive technique became main procedure for chest wall deformities; however, selection of proper indications and adequate surgical method is crucial for the successful and safe correction. Thoracic cage is a dynamic model comprising mechanics of sternum, ribs and spine. Future research should focus on comprehensive understanding of the thoracic cage to predict responses to correction for the satisfactory results.

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