



# Combining the best of both worlds: sternal elevation for resection of anterior mediastinal tumors through the subxiphoidal uniportal video-assisted thoracoscopic surgery approach

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The field of thoracic surgery continues to evolve with the development of innovative techniques aimed at improving patient outcomes and safety as well as minimizing surgical trauma. The subxiphoidal uniportal approach for anterior mediastinal tumor resection with the use of a modified sternum retractor is one such improvement. This approach is safe and feasible for removal of anterior mediastinum tumors and may decrease postoperative pain for faster patient recovery. This paper reviews the use of sternal elevation as an adjunct technique in subxiphoid uniportal video-assisted thoracoscopic surgery (VATS) resection of anterior mediastinal masses.

The classic surgical approach for the resection of mediastinal tumors is a conventional median sternotomy (1). However, within the past years, VATS has proven to be a highly safe and effective alternative technique for the resection of anterior mediastinal tumors, additionally it has shown to be associated with reduced surgical trauma and a lower risk of postoperative complications (2). VATS can be performed through either an intercostal or subxiphoidal

approach. In clinical practice, the right intercostal approach is preferred over the left, as the right pleural cavity is relatively larger, and thus surgical vision is not blocked by the heart or aortic arch. Although a growing body of literature suggests that left and middle anterior mediastinal tumors can be safely removed via the left lateral intercostal approach (3-5), the right thoracic approach is associated with a lower pleural drainage time and hospital stay (6,7). In general, compared to median sternotomy, it is more difficult to identify the contralateral phrenic nerve and reach the upper pole of the thymus during intercostal VATS (either via the right or left thoracic approach). There may also be a higher incidence of (chronic) intercostal neuralgia which can occur due to intercostal nerve injury from the port placement (8).

The subxiphoidal VATS approach can be performed with or without the use of additional intercostal or cervical incisions. This approach was first introduced by Arom *et al.* attempting to enhance surgical exposure of the anterior mediastinum and reduce postoperative pain (9). The latter

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was demonstrated by Mao *et al.*, as well as other studies which compared subxiphoidal to intercostal VATS (10-13). Other perioperative results were similar. It was also noticeable that in the multiportal intercostal VATS group of their retrospective cohort, an additional subxiphoidal incision was required in a large subset of patients (29%) due to the tumor size (10).

Several studies even suggested that the subxiphoidal approach is beneficial in terms of oncological outcomes in the resection of malignant mediastinal tumors as improved surgical exposure facilitates complete removal of tumor-associated fat tissues (14-16). However, the subxiphoidal approach also comes with potential disadvantages. Accessing the mediastinum from a caudal perspective can be challenging specifically regarding the dissection of the retrosternal plane (10). Particularly in obese patients or those with a narrow mediastinum and increased chest wall rigidity, this can prove to be difficult. Furthermore, the subxiphoidal approach requires longer instruments when compared to those used in uniportal or multiportal intercostal VATS, requiring additional investments.

To simplify the dissection of the retrosternal plane via a subxiphoidal access and increase the retrosternal space, sternal elevation can be an advantage when applied. Over the years, various sternal elevation techniques have been developed. Mao *et al.* shared their institutional experience with a modified sternum retractor consisting of a traction frame and a single hook placed under the sternum via a subxiphoid incision (10). Additionally, they recommend using a sealed incision protector facilitating CO<sub>2</sub> insufflation to further enhance surgical exposure. The advantages of this modified sternum retractor over previously proposed ones are a lower complication risk as well as diminished postoperative pain, as no subcostal or intercostal incisions are required (11,17-19). In the last decade, sternal elevation has predominantly gained popularity in pectus excavatum repair by the Nuss procedure and cardiac surgery to optimize exposure and access to the thoracic cavity by enabling safer and more efficient surgery. The experience and techniques employed in these specific surgical fields may facilitate subsequent application in subxiphoidal VATS. Haecker *et al.* systematically reviewed several sternal elevation techniques used during minimally invasive repair of pectus excavatum (20). These include the Rultract retractor (Rultract Inc., Cleveland, OH, USA) in combination with a perforating bone clamp that is placed on the sternum as introduced by Jaroszewski *et al.* (21), and the vacuum bell which uses negative pressure to lift the sternum

as proposed by Haecker *et al.* (22). In addition, Park and Rim developed a technique for sternal elevation using stainless steel screws that are inserted into the sternum (23). Nevertheless, the crane technique as previously reported by Park *et al.* remains the most commonly applied sternal elevation technique during minimally invasive repair of pectus excavatum (24). This technique involves the placement of a steel wire through the anterior cortex of the sternum, which is attached to a retractor. Future advancements of the crane technique to improve its anterior chest wall lifting capacity, include multipoint fixation, or the use of more rigid or bilateral table-mounted frames. Sternal elevation is widely applied in pectus excavatum repair as it not only facilitates intrathoracic visualization and safe mediastinal passage (minimizing pericardial trauma or cardiac injury) by increasing the retrosternal space and enhancing thoracoscopic exposure, but it also decreases the forces applied at the hinge points during bar flipping which prevents intercostal muscle stripping. Sternal elevation furthermore enables better preoperative planning and molding of the Nuss bar(s) as a temporary correction of the pectus deformity is established. The trend over the past decade among experienced surgeons is that sternal elevation is applied without reservation in pectus excavatum repair, especially in moderate to severe cases or in patients with increased chest wall rigidity (i.e., adult patients or redo-surgery). The effect of the crane was quantified in the study by de Loos *et al.* in pectus excavatum patients (25). Though an overall 78% reduction of the sternal depression can be acquired, its effect lessens with increasing pectus depth. However, in severe cases, even a minor absolute lift can highly increase the safety of the procedure. In addition, the crane technique establishes an elevation of the anterior chest wall over a large surface area.

Possible sternal elevation-related complications are bleeding, iatrogenic injury, cut-out, sternal fracture, and infection. However, these complications are rarely reported in the literature. Haecker *et al.* conducted a systematic review encompassing the use of sternal elevation during minimally invasive repair of pectus excavatum (20). In their review of over 3,000 cases, no cardiac or mammary injuries were found, and the occurrence of sternal elevation-related complications was low. They advocated the adoption of sternal elevation techniques to ensure enhanced safety.

The application of sternal elevation techniques for subxiphoidal uniportal VATS may benefit from experiences in improvements learned from the field of chest wall surgery. The modified sternum retractor as described in

the article by Mao *et al.*, is comparable to the sternal lift system for pectus excavatum repair as developed by Johnson *et al.* (26). However, in chest wall surgery, this system is not widely used as the other techniques provide a better lift over the full length of the sternum instead of a tilt from the lower portion of the sternum. Also, instrument positioning for the mediastinal tumor removal while providing an optimal sternal elevation could be easier when sternal elevation equipment is placed more remote from the operative site. Furthermore, to diminish the risk of intraoperative collapse of any sternal retractor, maximum stability of the construction used is essential.

Mao *et al.* are to be commended for their study on the implementation of a modified sternum retractor in the surgical management of anterior mediastinal tumors via the subxiphoidal VATS approach. Their implementation of this sternal elevation technique is an important step in improving surgical access and safety. However, to further enhance the operative technique, it may be worthwhile to consider incorporating sternal elevation approaches utilized in cardiac and chest wall surgeries. These established techniques have demonstrated effectiveness in elevating the sternum and may offer valuable insights for optimizing the subxiphoidal approach in anterior mediastinal tumor resections.

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