



## Special series: minimally invasive treatment of pectus deformities

Deformities of the anterior chest wall constitute approximately 90% of all congenital chest deformities (1) and are considered the phenotypical consequence of anomalous chest wall growth. Since the majority is accounted for by pectus excavatum and pectus carinatum, they are often referred to as pectus deformities, being the topic of the present special series. Evolution in the management of congenital chest wall deformities has made significant progress over the past two decades, and improved patient outcome. Here, the treatment of pectus deformities in a dedicated multidisciplinary setting is the most important pillar of present time, but in retrospect least recognized evolution. Although the common goal of this management is to achieve anatomical position of the anterior chest wall, the clinical picture, diagnostic work-up and treatment options vary depending on the specific type of deformity.

Provided the relatively high incidence and prevalence, our first focus is on pectus excavatum. This deformity was first documented 2400 Before Christ, as appreciated from a relief from the Old Kingdom of Egypt (2), however was not recognized as a medical condition until 1870 (3). Since its first surgical correction, attempted in 1911, surgery was popularized by Ravitch who advocated radical sternal mobilization without external traction that was priorly used to keep the sternum in place (4). However, only after the introduction of the minimally invasive procedure proposed by Donald Nuss in 1986 (5) did the surgical treatment of pectus excavatum ramp. So did the emphasis on recognition and diagnostic work-up, including the introduction of the Haller index as a determinant of pectus severity aimed to select patients for pectus excavatum surgery (6). Later different objective criteria were added to select patients that would benefit from surgery, accentuating the cardiopulmonary consequences of pectus excavatum (7). Despite over 275 papers have been published in the past decade on functional changes prior to and after surgical correction of pectus excavatum, many are retrospective small cohort studies that are heterogenous and of low evidential quality (8). This generally poor evidence constitutes the basis of the ongoing debate on the cardiopulmonary impact of pectus excavatum and whether patients may benefit from surgical repair. Consequently, the National Health Service (NHS) of the United Kingdom has even decommissioned the routine surgical treatment of pectus excavatum (9). This has had far-reaching and serious effects as well as political interference. Even more strikingly, this decision has potentially profound implications for other countries as they may follow the NHS's proposal. In opposing view, pectus excavatum is too often considered as an esthetic disorder and associated body image disturbances while among surgeons it is clearly acknowledged that subjective improvement in exercise intolerance is often reported after minimally invasive repair of pectus excavatum (7). Thus, despite recent efforts and advances over time, as well as current believes, the lack of convincing high-quality evidence remains a critical concern that could potentially interfere with future surgical management of pectus excavatum.

Pending this ongoing debate, conservative treatment (such as the vacuum bell) is also being looked at with increasing attention. Still, surgical treatment remains the accepted treatment of choice in the absence of long-term results on conservative management and the fact that it only suits part of the patient population. Thus, to eventually position conservative treatment options in the current treatment algorithm, high-quality and long-term evidence is equally warranted.

Considering pectus carinatum, the little brother on the block that accounts for fewer than 10% of pectus deformities, there seems to be less controversy. Although pectus carinatum was described by Hippocrates as a sharply pointed chest with associated respiratory problems (10), today the deformity is considered a purely cosmetic disease without cardiopulmonary impact, albeit a portion of patients may exert tenderness at the site of maximal protrusion. This applies particularly to prone sleepers. The commonly accepted treatment algorithm includes (dynamic) bracing therapy followed by minimally invasive repair through the Abramson procedure upon bracing failure, as introduced in 2005 by Horacio Abramson (11). In cases of relatively high chest wall stiffness or severe deformity, where bracing therapy is not expected to achieve sufficient effect, primary surgical repair is often opted. Following surgical treatment by the Abramson procedure up to 9 out of 10 patients report excellent to satisfactory esthetic results (12). It has however to be noted that this regards low-quality patient-reported evidence, hence the critical comments about convincing evidence can be applied to the entire range of pectus deformities.

Overall, the quality of evidence regarding the niche subject of pectus deformities remains relatively low with many unexplored paths, but on the same note many opportunities. Conversely, one can also look at it in terms of existing

progressive attention to pectus deformities that are regarded as relatively young diseases, revealing deficiencies with the ultimate goal of optimizing management based on sound scientific evidence which is a natural movement in time. In conjunction with the fact that there is unequivocal agreement on minimally invasive repair as currently accepted standard for treatment of pectus deformities, the goal of the present special series on minimally invasive treatment of pectus deformities is to provide a comprehensive overview of the present state and initiate future research and elucidate non-convincing evidence.

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Jean H. T. Daemen



Frank-Martin Haecker



Erik R. de Loos

**Jean H. T. Daemen<sup>1</sup>, MD**

(Email: [j.daemen@zuyderland.nl](mailto:j.daemen@zuyderland.nl))

**Frank-Martin Haecker<sup>2,3</sup>, MD, PhD**

(Email: [frank-martin.haecker@kispisg.ch](mailto:frank-martin.haecker@kispisg.ch))

**Erik R. de Loos<sup>1</sup>, MD, PhD**

(Email: [e.delooos@zuyderland.nl](mailto:e.delooos@zuyderland.nl))

<sup>1</sup>Division of General Thoracic Surgery, Department of Surgery, Zuyderland Medical Center, Heerlen, The Netherlands;

<sup>2</sup>Department of Pediatric Surgery, Children's Hospital of Eastern Switzerland, St. Gallen, Switzerland;

<sup>3</sup>Faculty of Medicine, University of Basel, Basel, Switzerland.

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