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Implications of Pediatric Chest Wall Surgery on the Risk of Developing of Scoliosis

Rachel White, Michael Ginzburg*

Sacramento, USA
Email: *mginzburgco004912@yahoo.com

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Abstract

Scoliosis, a three-dimensional deformity of the spine, is commonly encountered in orthopedic and multidisciplinary settings, with idiopathic scoliosis being the most diagnosed form. Complications arising from thoracic chest wall surgeries, including thoracotomy and sternotomy, often include scoliosis among other complications. However, reported prevalence rates of scoliosis following chest wall surgery vary widely. This study aims to compare the prevalence of scoliosis in children who have undergone chest wall surgery to the prevalence of idiopathic scoliosis in the general population, as well as to observe gender ratios and curve direction in post-surgery scoliosis cases. A systematic review was conducted using PubMed and Scopus databases to identify relevant studies. Inclusion criteria comprised studies reporting scoliosis prevalence post chest wall surgery with follow-up times post-surgery. The search yielded 30 articles, all retrospective institutional cohort studies published between 1975 and 2024. Despite heterogeneity in study characteristics, the analysis revealed a 19% prevalence of acquired scoliosis among 5722 children who underwent chest wall surgery, higher than the reported 1% - 4% prevalence in the idiopathic population. Only three studies showed prevalence rates similar to the idiopathic population, possibly due to short follow-up periods. Further research with longer follow-up into skeletal maturity is warranted to better understand the implications of pediatric chest wall surgery on scoliosis development.

Keywords

Thoracotomy, Sternotomy, Scoliosis

1. Introduction

Scoliosis is a tri-planar deformity of the spine, which is at least 10 degrees and is

routinely seen in orthopedic and multidisciplinary settings [1]. Most broadly, the scoliotic curves can be described as congenital, neuromuscular, degenerative, or idiopathic; with idiopathic being the most diagnosed [2]. The prevalence of adolescent idiopathic scoliosis is approximately 2% - 4% of the adolescent US population and less than 1% in the early childhood population [3]. In the thoracic spine, right-sided curves are more common, while the sex ratio of progressive idiopathic curves is 10:1 female to male [3]. Complications resulting from thoracic chest wall surgeries are widely reported with scoliosis being among the complications. 19% prevalence of the incidence of scoliosis in the post-surgical population was reported among the studies included in this research. However, there appears to be a wide variance in the reported prevalence of scoliosis secondary to chest wall surgery (thoracotomy, sternotomy). This can be attributed to changes in surgical and rehabilitation techniques over time and in different countries, different follow-up schedules, and varying scoliosis detection techniques used. Detection, monitoring, and the use of orthotic interventions are important in the management of scoliosis and if left unmanaged, can potentially lead to curves increasing to a surgical magnitude. The aim of this study is to compare the reported prevalence of scoliosis among children who had chest wall surgery to the prevalence of idiopathic scoliosis in the general population. Also, to observe the gender ratios and curve direction of scoliosis brought on by chest wall surgery as compared to the idiopathic population.

2. Patients and Methods

Initially, a review of PubMed digital library was conducted using the search terms "scoliosis", "thoracotomy", "sternotomy", "congenital heart disease", "congenital diaphragmatic hernia", "aortic coarctation", and "patent ductus arteriosus". Congenital diaphragmatic hernia, in the end, was removed from the search as the procedure to repair this diagnosis requires abdominal surgery, not a chest wall. Reference Lists of all included articles were also searched for additional studies. In addition to keyword searches, the authors used the citation-based database Scopus using articles identified by the authors as highly relevant, searched forward and backward and related search based on references.

Two reviewers (RW, MG) screened the abstracts of all potentially relevant studies. In cases of disagreement, both reviewers discussed the discrepancies and came to a consensus conclusion. After screening, all relevant full-text articles were reviewed independently by both reviewers. Studies were identified for inclusion and reviewed in their entirety by the two reviewers using a data extraction program, Covidence. Inclusion criteria included reporting the prevalence of scoliosis after chest wall surgery and reporting follow-up times post-surgery. Congenital vertebral anomalies were excluded from the total number of chest wall surgery patients with scoliosis, and any article that included vertebra anomalies in their count without distinguishing was excluded. Search diagnoses were chosen based specifically on pediatric diagnoses involving chest wall sur-

gery. Patients must have been operated on as a child. The prevalence of scoliosis in the overall surgical population was analyzed. The descriptions of the scoliotic curves as well as sex ratios within the surgical population were also examined and compared to the population norm.

3. Results

The original search in 2022 yielded 12 studies for inclusion. After redefining our inclusion criteria, 6 of the original studies were excluded. Once the second search described previously was completed, 30 articles were included for analysis. All studies were retrospective institutional cohort studies. Studies were published between 1975 and 2024. There was a large amount of heterogeneity within the included studies regarding surgical era, age at surgery, type of chest wall surgery, age at follow-up post-surgery, the definition of scoliosis, and even measurement of scoliosis, making pooled analysis of data inappropriate.

Of the 30 studies included, 12 reported curve direction [4]-[15]. Of the twelve that reported curve direction, 46 percent were reported as left thoracic. This varies from the idiopathic population in which thoracic curves have been reported as high as 90 percent in the right direction [16].

8 of 30 studies reported the number of males versus females with scoliosis after pediatric chest wall surgery. These eight studies reported a total of 181 patients with scoliosis, and 73 of those being male. This produces a 42% rate of scoliosis among males who have had chest wall surgery, much larger than that of the idiopathic population [17].

4. Discussion

All 30 studies comprised 5722 children with 1093 (19%) reported as having acquired scoliosis after undergoing some type of chest wall surgery, namely thoracotomy or sternotomy [4] [5] [6] [8]-[13] [15] [18]-[36]. This is higher than the idiopathic population which has been reported to be 1% - 4% [3]. Only 3 out of 30 studies show an overall prevalence rate of scoliosis in patients who have undergone chest wall surgery to be similar to that of the idiopathic population [19] [23] [32]. One explanation for these low reported numbers could be the fact that the follow-up period in these studies was rather short, ranging from 2.8 years old at the time of follow-up post-surgery to 10 years old. Perhaps later follow-up would find an increase in the number of patients that acquire scoliosis post-surgery into skeletal maturity. At 2.8 years - 10 years old, patients have yet to reach their peak growth velocities which are often when we see curves appear and/or progress. All three studies that reported a prevalence of scoliosis similar to the general population noted that a limitation to their study was that their patients were still skeletally immature at follow-up and must wait until the end of their growth to assess their spine [19] [23] [32]. One study noted another limitation being that only chest radiographs were analyzed, possibly missing some lumbar or thoracolumbar curves [32]. One study, despite reporting the prevalence of scoliosis in

post-chest wall surgery patients as similar to the general population, still recommended these patients at a minimum be adequately counseled about the risks of developing scoliosis and referral to a spine specialist if any early suspicion should arise [19]. Ninety percent of the studies reported a prevalence of scoliosis after chest wall surgery over that of the general population, ranging from 7% - 68%.

Of the studies that reported curve direction (12 of 30) [4]-[13] [15] [22] [29] [31] [36], 46% report left thoracic curves. This also differs from the idiopathic population being mainly right thoracic curves [37]. There appears to be a different female-to-male ratio of acquired scoliosis post chest wall surgery than the progressive idiopathic population, resembling close to a 1:1 ratio as compared to up to 10:1 in the idiopathic population [17]. One reason for this is that the underlying causes for the need for chest wall surgery are relatively equal among gender groups. This observation can be used to support the argument that the pathomechanics of scoliosis development vary between the idiopathic and post-surgical populations. Post-surgical scarring and adhesions have been described in the studies reviewed as contributing to the onset of scoliosis development. Additionally, the international research publications reviewed include a range of genetic variances in the populations studied. Further research into this relationship is recommended.

5. Conclusion

Considering curves can occur post chest wall surgery in the growing child at a rate higher than the general idiopathic population, increased screening for scoliosis should be warranted for this population in an attempt to manage with an orthosis during skeletal immaturity for best outcomes. Further research with longer follow-up into skeletal maturity is warranted to better understand the implications of pediatric chest wall surgery on scoliosis development.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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