CASE REPORT

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Pediatric anterior thoracic wall reconstruction: a successful case of extensive resection and repair

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Abstract

Background Thoracic tumors are a challenge for pediatric surgeons. They comprise a heterogeneous group of neoplasms classified based on histological variety, location, presentation, biological behavior, treatment response, and prognosis. Primary tumors of the thoracic wall in children and adolescents are sporadic, accounting for only 1–2% of all pediatric thoracic neoplasms, with two-thirds of them being malignant.

Case presentation We present the case of a 16-year-old male patient with osteoblastic osteosarcoma localized in the right anterior rib cage. The patient underwent extensive tumor resection using titanium bars.

Conclusion Thoracic reconstruction following extensive resection in pediatric cancer patients has been underexplored and poorly described. Nevertheless, it has been demonstrated to be feasible, particularly considering the 5-year survival rate of 60% following tumor resection. This approach helps prevent anatomical and physiological complications that may arise without reconstruction. We report a successful single-stage resection and thoracic reconstruction case in a pediatric patient. This case underscores the importance of considering reconstruction in patients with thoracic tumors, as it can contribute to improving prognosis and preventing associated complications.

Keywords Chest wall tumors, Primary chest wall tumors, Chest wall pediatric neoplasm, Case report

Background

Thoracic tumors pose a challenge for pediatric surgeons as they encompass a heterogeneous group of neoplasms classified based on histological variety, localization,

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presentation, biological behavior, treatment response, and prognosis [1]. In children and adolescents, primary tumors of the thoracic wall are sporadic and account for only 1–2% of all pediatric thoracic neoplasms. Among these, approximately 60% are malignant sarcomas, with around 55% originating from bones or cartilage and 45% from soft tissues (56% Ewing sarcoma, 25% rhabdomyosarcoma, and the remaining cases include osteosarcoma, fibrosarcoma, chondroblastoma, or metastatic tumors, mainly lymphomas) [2, 3].

The 5-year survival rate after tumor resection is 60% [4, 5]. The clinical presentation is typically associated with the site and nearby affected organs, with respiratory or digestive compressive symptoms and sometimes vascular or neurological symptoms. Patients may also experience pain and systemic signs related to the tumor and its components [6].



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Thoracic reconstruction following extensive resection is well-documented in adult patients, but there is a severe lack of studies in pediatric patients. It is essential to consider the age, size, and underlying pathology, as well as the preservation of function, stability, and esthetics, to ensure progressive growth and development of the patient while not interfering with their oncological treatment [7, 8]. Resection and reconstruction of the thoracic wall are necessary for invasive and infiltrative oncological processes, whether primary or metastatic [9].

Case presentation

We present the case of a 16-year-old male patient diagnosed with osteoblastic osteosarcoma in the anterior and right lateral chest wall. The patient presented with a progressively growing tumor within 3 months on the right lateral side of the costal wall, with no other signs or symptoms at that moment. During his first admission, a thorax computed tomography was performed, which detected an osteoblastic tumor of $13 \times 16.5 \times 16.5$ cm originating from the fifth costal arc. The tumor extended to the third, fourth, and sixth ribs, as well as the soft tissues of the chest. It exhibited exophytic growth into the thoracic cavity, causing compression on the lung and atelectasis. A tumor biopsy was performed using a coaxial technique guided by ultrasound (Fig. 1).

The patient's multidisciplinary approach involved neoadjuvant chemotherapy for 3 months to assess cytoreduction for the final resection of osteoblastic osteosarcoma, as reported by the histopathological study. The patient



Fig. 1 Diagnostic imaging approach of the patient. A Posteroanterior chest radiograph showing a radiopaque image dependent on the right costal grid, corresponding to the tumor, with areas of radiopacity in the right lung that do not obscure the cardiac silhouette anterior to the heart. B Image of the patient with increased volume in the anterior and lateral right chest. C Chest and abdomen computed tomography, axial views at the level of the largest tumor extension. A heterogeneous solid lesion with central calcification originating from the anterolateral costal arches of the 3rd to 5th ribs is observed, expansively extending into the lung parenchyma, involving the entire extent of the thoracic wall from the inside to the outside, causing loss of normal anatomy and function. D Coronal view

completed a chemotherapy regimen for tumor control and cytoreduction with a low response.

As this type of tumor tends to progress rapidly, it was necessary to remove the entire tumor without delay. The imaging showed that the cancer affected more than three costal arcs, which made it a candidate for reconstructive surgery due to the possibility of an unstable thorax. Therefore, it was decided to perform a wide resection of the costal tumor and reconstruct the affected area using computed tomography for evaluation and surgical planning. This was done by the oncologic surgery service in collaboration with the pediatric thoracic and plastic surgery services (Figs. 2 and 3).

Surgical technique

The patient was placed in a left lateral supine position to expose the right chest wall. Since the right lung was suspected to have adhered to the tumor, selected intubation was performed by the anesthetic team. A diamondshaped skin incision was made, starting from the biopsy site in the anterior chest wall, and dissection was continued with at least a 1 cm margin around the lesion (Figs. 3 and 4). The pectoralis major muscle, the anterior portion of the latissimus dorsi muscle (posterior border), and the serratus anterior muscle were resected, extending towards the sternal border (medially) and the clavicle (superiorly). The inferior border of the pectoralis major muscle was preserved (inferiorly). Subsequently, the third, fourth, and fifth ribs, as well as the right middle lobe, were on bloc resected using a cutting linear stapler, ensuring an adequate surgical margin. Once the tumor was resected, the surgical site was thoroughly rinsed to ensure cleanliness and remove any tumor residue. The costal wall was reconstructed using the same surgical procedure (Fig. 5). A hydrogel mesh was placed and secured to all the borders using continuous non-absorbable 1-0 sutures.

Additionally, bone reconstruction was carried out using four grade 2 titanium bars. The first bar supported the entire structure and was fixed with titanium rib



Fig. 2 Intraoperative images of the surgical resection. A Resection and initiation of tumor extraction with macroscopically negative margins. B Resection of the lesion, including the site of the previous biopsy scar, with respective margins of at least 1 cm. C Complete extraction of the tumor from the thoracic wall, including right middle lobectomy, showing the residual anatomical defect



Fig. 3 Diagram of the chest wall osteosarcoma. The tumor originates from the 4th costal arc, extending through the 3rd, 5th, and 6th arcs with intimal contact with the right lung. This diagram shows the expansive growth of the tumor

clips from the mid-third of the clavicle to the sixth rib. Three additional bars were placed from the support bar to the edges of the previously resected ribs (third, fourth, and fifth) and fixed similarly with titanium clips. Once the titanium structure was in place, skin and pectoralis major muscle flaps were created, taken from the abdominal region and part of the serratus anterior muscle to cover the prosthetic material and complete the surgical procedure.

Immediate postoperative course

The patient remained in the intensive care unit for 4 days after surgery and was subsequently transferred to a regular room on the floor. During their stay in the intensive care unit, stability in the chest wall and excellent esthetic recovery were observed (Fig. 5). Currently, the patient is under surveillance and continues to receive chemotherapy treatment as part of their care plan.

Discussion

It is estimated that 60% of thoracic wall tumors are cancerous. These tumors can originate from the bone in 55% of cases, while 45% are from soft tissue. The overall success rate of treatment is 60%, but there is a recurrence rate of 50%. The most typical symptoms are a growing tumor and occasional pain. Tumors can be classified based on size, and those less than 3 cm in diameter can be removed. However, when the tumors are more extensive, an incisional biopsy with neoadjuvant is recommended.

Malignant tumors of the chest wall can either be primary tumors that directly invade or metastatic lesions. Although osteosarcoma is rare in the thoracic region, it remains the most common bone tumor in pediatric patients. As a result, there needs to be more literature on its management in this area [10, 11].

Among the differential diagnoses, the most common is Ewing's sarcoma, formerly known as PNET, which is considered the most common rib cage tumor. In second place is osteosarcoma, followed to a lesser extent by chondrosarcoma. Soft tissue tumors such as rhabdomyosarcoma or Askin's can also be included.

However, the importance of performing a wide radical resection [11-13] is recognized to prolong survival, reduce mortality, and decrease the rate of postoperative recurrence [14]. Osteosarcoma can exhibit aggressive behavior, making appropriate pre- and postoperative management crucial to achieve effective local control before surgery.

The surgical approach for chest wall tumors has two main objectives: complete tumor resection with negative margins of bone and soft tissue, which is the most important prognostic factor for improving patient survival, and reconstruction to restore proper ventilatory function, prevent deformities, and allow adequate mobility of the



Fig. 4 Diagram of the chest wall osteosarcoma resection in coronal and axial views. The pink arrow refers to the incision made on the skin around the biopsy scar. The blue arrows show the muscle where the flaps were made later to close the defect. The black arrow indicates the dissection and resection around the tumor only with clean margins under the healthy skin and muscles

shoulder girdle and protection of internal organs [15, 16]. Resection and reconstruction of the chest wall due to tumors have been described since the late 19th century, with pioneering cases reported at that time [17]. Medical centers like the Memorial Sloan Kettering Cancer Center in New York have reported successful chest wall resection and reconstruction cases using synthetic materials [18–20]. However, these cases are less frequently reported in the literature.

Multiple techniques for chest wall reconstruction have been described, and their choice depends on the resources and experience of the surgical team. Bone reconstructions can range from simple procedures to complex ones, including synthetic prosthetic and bioprosthetic materials, steel, titanium, autografts, allografts, or xenografts. On the other hand, soft tissue reconstruction can be achieved through primary skin closure, skin autografts, flaps, or a combination of techniques [21, 22]. It has been observed that using rigid materials, such as prostheses, is recommended for significant defects or critical areas of the thorax. In contrast, less severe biological materials, such as meshes, can be used for more minor defects [23–25].

It is essential to mention that chest wall reconstruction aims not only for patient survival but also to improve their quality of life by restoring thoracic function as close to normal as possible [26, 27].

Before the surgical intervention, a multidisciplinary study and evaluation of local disease control are necessary. This involves performing imaging studies such as computed tomography or magnetic resonance imaging to assess anatomy and tumor characteristics and the presence of metastasis. Additional examinations such as positron emission tomography (PET scan), bone marrow aspirates, and bone scans may also be conducted [28, 29]. Neoadjuvant chemotherapy can be helpful in most



Fig. 5 Images of evolution after surgery. **A** Placement of the first support bar from the upper portion of the clavicle to the 6th rib. **B** Subsequent fixation of 3 additional titanium bars from the support bar to the dorsal region, all fixed with titanium clips. **C** Posteroanterior chest radiograph in the postoperative period. **D** Chest tomography in reconstruction, both images to confirm fixation and position of the prosthetic material. **E** Image of the patient in the immediate postoperative period with pleural drain and sterile dressing. **F** Patient 21 days after surgery, visiting for suture removal, satisfied with the esthetic results and unaltered function. **G** Patient at 2 months postoperatively with a healed wound

tumors, such as Ewing sarcoma, rhabdomyosarcoma, and osteosarcoma [30]. Primary incisional biopsy is not always recommended, as it may cause tumor dissemination in some cases [31]. If the disease is metastatic, the patient will not be a candidate for initial surgery [32–34].

Ensuring resection margins of at least 1 cm is essential, and preoperative embolization can be considered in highly vascularized tumors [35, 36].

During the early postoperative period, the development of complications such as wound dehiscence, infections, or hematoma should be monitored. In the absence of complications, adjuvant chemotherapy is recommended based on the degree of tumor resection [37]. There is a recurrence risk of approximately 25% at the primary site, but recurrences in other regions are rare [38]. The most frequently reported postoperative complications that should be avoided as much as possible include scoliosis, chronic pain, and restrictions in respiratory movements, as this can interfere with adjuvant chemotherapy and increase the risk of recurrence [39, 40].

Conclusion

In conclusion, this reported case is the first in our center where massive resection and reconstruction of a thoracic tumor were performed in a pediatric patient. The procedure was carried out in a single surgical setting. It achieved negative margins and the placement of rigid prosthetic material without postoperative complications related to the disease or the procedure. The results were highly satisfactory regarding quality of life and esthetics.

The main objective of this case report is to share our experience, presenting this alternative as a safe option with excellent outcomes, especially considering the low incidence of this type of pathology. Additionally, it aims to contribute to the description of specific surgical techniques for such cases.

It is important to note that each case is unique and should be approached individually. The experience and resources available at each medical center can influence treatment options and the choice of surgical techniques. However, this case report provides valuable information that can assist other healthcare professionals in dealing with similar situations and considering appropriate therapeutic approaches to achieve optimal results.

Abbreviation

PET scan Positron emission tomography

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Not applicable.

Authors' contributions

NCI was responsible for data collection, data management, sequence alignment, and initial manuscript drafting. AGB and IVG contributed to the clinical aspects of the study and provided patient treatment. AGB and IVG participated in patient treatment, sequence alignment, and manuscript drafting. SB contributed to the study design, performed statistical analysis, and provided critical input. SB contributed to the study design, coordination, and manuscript drafting. All authors have read and approved the final manuscript.

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Availability of data and materials

The data and materials used in this study are available upon request. Due to restrictions on sharing the data publicly, a direct link to the dataset cannot be provided. However, all relevant data and materials necessary to replicate the study's findings will be made available upon reasonable request to the corresponding author. Please contact Sofia Brenes Guzmán at sofcxped@gmail. com for further inquiries regarding data and materials access.

Declarations

Ethics approval and consent to participate

This article presents a case report involving a pediatric patient with costal osteosarcoma and its management. The study was conducted in compliance with ethical principles, including the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from the patients' parents or legal guardians for the publication of their cases and accompanying images. The need for ethics approval was waived by the Hospital Inner Committee, as per their guidelines. The confidentiality of patient information was strictly maintained, and all data were de-identified prior to analysis. This study adheres to the ethical standards of our institution and ensures the privacy and rights of the patients involved.

Consent for publication

Written informed consent was obtained from the patients' parents or legal guardians for the publication of their cases and accompanying images.

Competing interests

The authors declare that they have no competing interests.

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