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Comparing Pediatric and Adult Primary Chest Wall Tumors

Ömer Faruk Demir,[1] Ömer Önal,[2] Alper Özcan,[3] Ayşe Ülgey,[4] Burcu Baran Ketencioğlu,[5] Mehmet Köse[6]

[1]Department of Thoracic Surgery, Ankara Atatürk Sanatorium Training and Research Hospital, Ankara, Türkiye
[2]Department of Thoracic Surgery, University of Erciyes Faculty of Medicine, Kayseri, Türkiye
[3]Division of Pediatric Hematology Oncology, Department of Pediatrics, University of Erciyes Faculty of Medicine, Kayseri, Türkiye
[4]Department of Anesthesiology and Reanimation, University of Erciyes Faculty of Medicine, Kayseri, Türkiye
[5]Department of Respiratory Medicine, University of Erciyes Faculty of Medicine, Kayseri, Türkiye
[6]Department of Pediatric Pulmonology, Faculty of Medicine, University of Erciyes, Kayseri, Türkiye

ABSTRACT

Objective: This study aims to evaluate the differences in surgical interventions and outcomes for primary chest wall tumors in pediatric and adult patient groups.

Materials and Methods: We reviewed records of patients operated on for primary chest wall tumors from January 2005 to June 2019. Patients aged 18 and younger were classified as pediatric (group I), while those above 18 were considered adults (group II). We analyzed demographic characteristics, histopathologic diagnosis, number of resected ribs, prosthetics requirements, complications, chemotherapy and radiotherapy applications, and related complications. The Kaplan-Meier method was used to analyze patient survival times, and the log-rank test was employed for comparing survival times between groups.

Results: Of the 71 patients who underwent operations for primary chest wall tumors in our clinic between January 2005 and June 2019, 20 were pediatric (28.2%) and 51 were adults (71.8%). The 5-year overall survival rates for pediatric and adult patients were 72.9% and 68.8%, respectively (p=0.683), while the 5-year disease-free survival rates were 76.0% and 69.0%, respectively, showing no significant differences (p=0.709).

Conclusion: Our findings indicate no significant differences between pediatric and adult primary chest wall tumors regarding disease-free survival times, overall survival rates, and surgical complications.

Keywords: Chest wall tumors, pediatric surgery, primary chest wall tumors, survival, thoracic surgery.

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Address for correspondence:
Ömer Faruk Demir.
Department of Thoracic Surgery, Ankara Atatürk Sanatorium Training and Research Hospital, Ankara, Türkiye
Phone: +90 312 356 90 00
E-mail: ofdemir@erciyes.edu.tr

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INTRODUCTION

Primary chest wall tumors (PCWTs), observed in both adult and pediatric patients, are quite rare, with an incidence rate below 2% in the population.[1,2] Generally, 45% of PCWTs are of soft-tissue

origin, while 55% originate from bone and cartilage tissue.[1] Although PCWTs are less prevalent in children, their potential for malignancy is greater.[3] The Ewing sarcoma family of tumors (ESFT), which includes Ewing sarcoma (ES), peripheral primitive neuroectodermal tumor (PNET), and Askin tumor, represents the most frequently encountered PCWTs in pediatric patients.[3] In contrast, benign chest wall tumors are less common in children.[4]

The prevalence of PCWTs is slightly higher in adults than in children, although rare in both groups. Chondrosarcoma and osteosarcoma are among the most frequently observed malignant PCWTs in adults, while chondroma, osteochondroma, fibrous dysplasia, and desmoid tumor are common in the benign category.[1,5] Treating PCWT in both groups poses significant challenges for surgeons due to the rarity of these tumors, the scarcity of literature, the lack of consensus on optimal treatment procedures, multimodal treatment requirements, considerations related to maturation in children, prosthesis applications, and associated risks.

In this study, we aim to evaluate the differences in surgical interventions and outcomes for PWCTs in pediatric and adult patient groups.

MATERIALS AND METHODS

This study was conducted with approval from the Erciyes University Clinical Research Ethics Committee (No: 2019/135). It included patients who underwent chest wall resection at our clinic from January 2005 to June 2019. Patients without a primary chest wall origin (e.g., metastasis, invasion) were excluded. Patients aged 18 and below were classified as pediatric group I, while those aged 19 and above were classified as adult group II. Patient data were acquired, and the two groups were compared regarding demographic characteristics, complications, number of resected ribs, prosthesis application, histopathologic diagnosis, and chemotherapy or radiotherapy administration.

Patients' statuses were cross-referenced with the national death notification system to ascertain their current living status. Only patients with malignant conditions from both groups were included in the calculations for survival and disease-free survival rates. Overall survival (OS) time was calculated from the date of surgery to the date of death or the last follow-up. Disease-free survival (DFS) time was determined from the date of surgery to the date of recurrence, death, or the last follow-up, whichever occurred first. IBM Statistical Package for the Social Sciences (SPSS) 26.0 software was utilized for data analysis. The Kaplan-Meier method was used to analyze patients' survival times, while the log-rank test was employed to compare survival times between groups.

RESULTS

Between January 2005 and June 2019, a total of 71 patients were diagnosed with PCWT in our clinic. Of these, 20 were pediatric patients (28.2%), and 51 were adults (71.8%). The mean age in the pediatric group was calculated as 11.25±5.5 years, and in the adult group as 51.29±13.6 years. The most frequently observed malignant tumors in the pediatric group were ESFT (ES n=3, PNET n=3, Askin tumor n=1) and chondrosarcoma in the adult group. The histopathological distribution of benign and malignant tumors is summarized in Tables 1 and 2. Among the adult patients, 23 (45.1%) had malignant tumors, while 11 (55%) of the pediatric patients were found to have malignant tumors.

Prosthesis application was required for 6 (30%) of the 20 pediatric patients, while 17 (33.3%) of the adult patients needed a prosthesis. Polytetrafluoroethylene (PTFE) grafts were most frequently used in both children and adults. A titanium bar was utilized for 6 (11.8%) adult patients. The average number of resected ribs was 1.65±0.87 in children and 1.50±1.13 in adults. The complication rate in adult patients was determined to be 41.2%, whereas complications were observed in 40% of the pediatric patients. The most common complications in both groups were postoperative bleeding and infections (Table 3).

Chemotherapy was administered to 9 (45%) pediatric patients and 12 (23.5%) adult patients. Two (10%) pediatric patients and 8 (15.7%) adult patients received radiotherapy. Group comparison data are summarized in Table 3.

The 5-year DFS rate was 76.0% in children and 69.0% in adult patients. No significant difference was observed in DFS between the adult and pediatric groups (p=0.709). The 5-year OS rates were 72.9% for adult patients and 68.8% for the pediatric group. No significant difference was found between the OS rates of the two groups using the long-range test (p=0.683). Mean survival times are summarized in Table 4, while OS and DFS rates are detailed in Figures 1 and 2.

DISCUSSION

PCWTs are a rare group of tumors, comprising only 0.04% of all cancers diagnosed annually in America.[6] Literature suggests that the malignancy rate of PCWTs ranges from 40% to 60%.[1,2,7]

In the study by Girelli et al.,[8] which predominantly included pediatric patients with a mean age of 13.7 years, malignancy was noted in all patients, with Ewing's sarcoma being the most common tumor. In Athanassidi's study of 41 patients, most of whom were adults, malignancy was detected in 18 patients (43%), with plasmacytoma being the most common tumor.[9] In the study by King et al.,[10] involving 90 patients with a mean age of 44.3 years, malignancy was noted in 71 pa-

Table 1. Histopathologic type of PCWT in pediatric patients

Tumor type	Patient number	Percent
Benign tumor	**9**	**45**
Aneurysmal bone cyst	1	5
Osteochondroma	3	15
Hemangioma	1	5
Granulomatous inflammation	1	5
Periostitis ossificans	1	5
Chronic inflammation	1	5
Enchondroma	1	5
Malignant tumor	**11**	**55**
Ewing's sarcoma	3	15
Primitive neuroectodermal tumor	3	15
Askin tumor	1	5
Osteosarcoma	1	5
Fibrosarcoma	2	10
Osteoblastoma	1	10
Total	**20**	**100**

PCWT: Primary chest wall tumors.

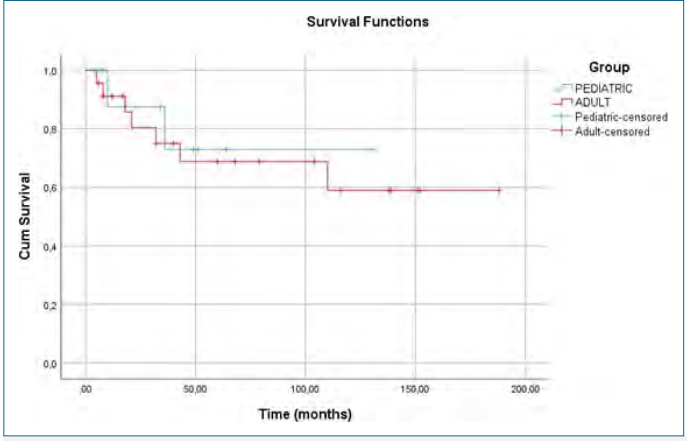

Figure 1. No significant difference was observed in the OS rates between the two groups when applying the log-rank test (p=0.683).

tients (78.9%), with malignant fibrous histiocytoma being the most frequent tumor. In Garber's study, 59 patients (53.6%) exhibited malignancy, with fibrosarcoma being the most common malignant tumor.[11] Histopathological distribution varies significantly in the literature among both adult and pediatric patient groups.

Table 2. Histopathologic types of PCWT in adult patients

Tumor type	Patient number	Percent (%)
Benign tumor	**28**	**54.9**
Hemangioma-cavernous hemangioma	4	**7.84**
Fibrous tumor	1	**1.96**
Langerhans cell tumor	2	**3.92**
Necrotizing granulomatous inflammation (TBC)	2	**3.92**
Lipoma	1	**1.96**
Osteoma	2	**3.92**
Chondroma-enchondroma	2	**3.92**
Fibrolipoma	1	**1.96**
Intraosseous lymphangioma	1	**1.96**
Osteofibrous dysplasia	1	**1.96**
Fibro osseous	2	**3.92**
Chondromatosis	1	**1.96**
Neurofibroma	1	**1.96**
Hibernoma	1	**1.96**
Paraganglioma	1	**1.96**
Fibrous dysplasia	3	**5.88**
Elastofibroma	2	**3.92**
Malignant tumor	**23**	**45.1**
Chondrosarcoma	6	**11.76**
Rhabdomyosarcoma	2	**3.92**
Malignant fibrous histiocytoma	3	**5.88**
Solitary plasmacytoma	4	**7.84**
Liposarcoma	1	**1.96**
Lymphoma	1	**1.96**
Synovial sarcoma	1	**1.96**
Fibrosarcoma	1	**1.96**
Osteosarcoma	1	**1.96**
Malignant tumor	1	**1.96**
Malignant melanoma	1	**1.96**
Spindle cell malignant tumor	1	**1.99**
Total	**51**	**100**

PCWT: Primary chest wall tumors.

No consensus has been reached regarding PCWTs requiring multimodal treatment, and there is still no optimal treatment method established. However, surgical resections are currently considered the primary component of treatment.[1] Thoracotomy is the general approach, while thoracoscopic surgery is applied rarely and by experienced surgeons in select cases of primary chest wall tumors.[12] Thoracoscopic surgery was suc-

Table 3. Group comparison data summarized

	Group I (pediatric patients)		Group II (adult patients)	
	Fre.	Per. %	Fre.	Per. %
Sex				
M	12	60.0	34	66.7
F	8	40.0	17	33.3
Status				
Alive	18	90.0	38	74.5
Dead	2	10.0	13	25.5
Diagnosis				
Benign	9	45.0	28	54.9
Malignant	11	55.0	23	45.1
Prosthesis				
Yes	6	30.0	17	33.3
No	14	70.0	34	66.7
Chemotherapy				
Yes	9	45.0	12	23.5
No	11	55.0	39	76.5
Radiotherapy				
Yes	2	10.0	8	15.7
No	18	90.0	43	84.3
Number of ribs				
0	2	10.0	9	17.6
1	6	30.0	18	35.3
2	9	45.0	18	35.3
3	3	15.0	2	3.9
4	–	–	3	5.9
5	–	–	1	2.0
Complications				
No	12	60.0	30	58.8
Yes	8	40.0	21	41.2
Bleeding	4	20.0	12	23.5
Infection	1	5.0	3	5.9
Pulmonary	2	10.0	6	11.8
Scoliosis	1	5.0	-	-
Prosthesis type				
PTFE	4	20.0	10	19.6
Polypropylene	2	10.0	1	2.0
Titanium	–	–	6	11.8

PTFE: Polytetrafluoroethylene. Fre: Frequency; Per: Percent.

Table 4. Means for survival time estimates

Group	Estimate	Std. Error	Logrank (Mantel-Cox)
Pediatric	101,292	17,476	p=0.683
Adult	128,699	17,971	

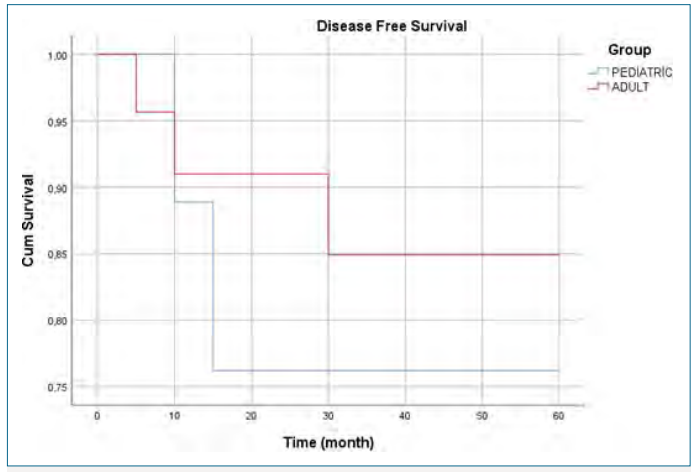

Figure 2. No difference was observed between the DFS rates between patients in the adult and pediatric groups (p=0.709).

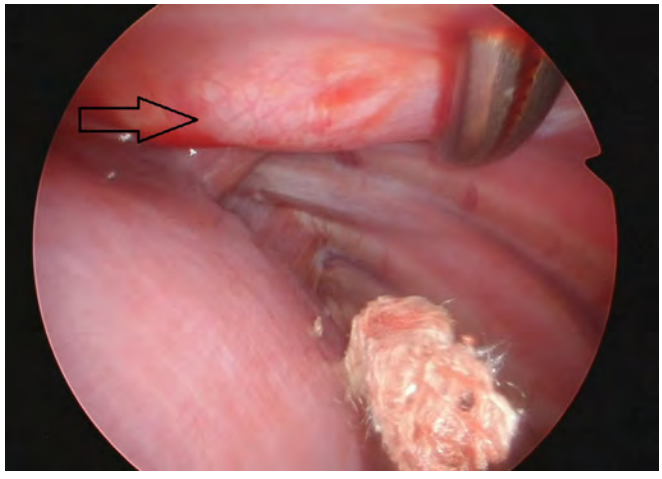

Figure 3. Surgical procedure on a 1-year-old patient for a lesion on the 9th rib, performed via thoracoscopy without any diaphragm damage. The lesion originating from the rib is indicated by an arrow.

cessfully performed on a 1-year-old patient with a lesion bordering the diaphragm (Fig. 3). Similarly, resection of the lung from the chest wall in an adult patient enabled the determination of the absence of invasion (Fig. 4).

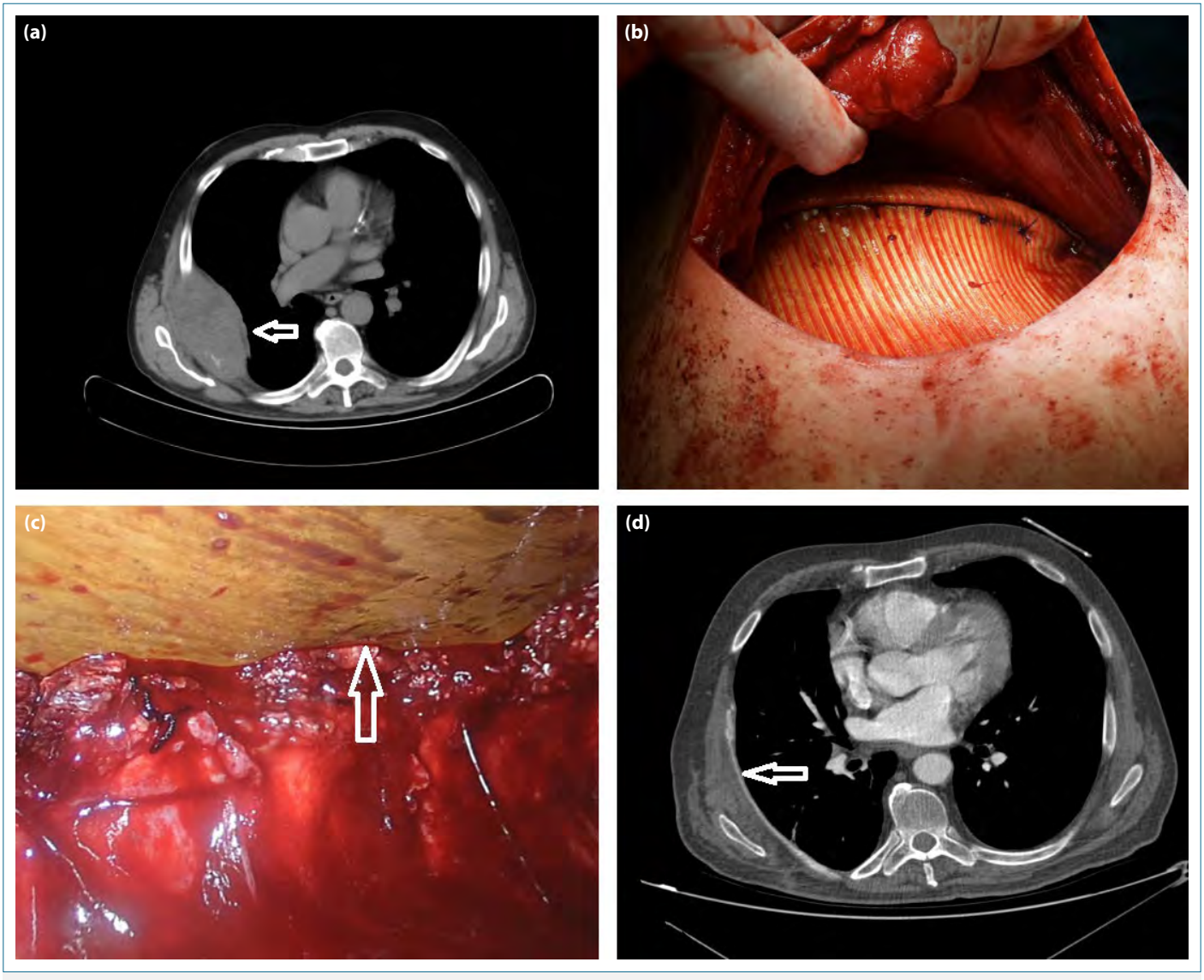

Figure 4. (a) Preoperative CT image of the patient, **(b)** intraoperative appearance of the PTFE prosthesis, **(c)** intraoperative thoracoscopic image of the patient, **(d)** CT image showing the prosthesis.

Surgical resection should ensure a negative surgical margin, as it is one of the most important factors impacting recurrence and survival time.[7] However, the extent of the surgical margin remains a matter of debate. In the pediatric group, the presence or absence of microscopic tumors at the surgical margin showed no significant impact on the prognosis of rhabdomyosarcomas.[13] The guidelines suggest a minimum surgical margin of 1 cm.[14] At our clinic, we remove chest wall tumors with a surgical margin of 1 cm for both pediatric and adult patients with benign tumors, at least 2 cm for malignant tumors, and 4 cm for high-grade tumors.

The general consensus is that reconstruction is not necessary for defects up to 5 cm at any location on the chest wall. However, for defects of 10 cm and larger, reconstruction is generally not required when the defect is located in a region with support above, such as below the scapula; for all other areas, reconstruction is necessary.[1,15,16] Currently, there is no optimal reconstruction material, but many different methods and materials can be utilized for reconstruction.[17–19] The first metal prosthesis used for chest wall rigidity was implemented in 1909.[20] Nowadays, titanium bars are often preferred for osteosynthesis due to their strength and bio- and Magnetic Resonance (MR) compatibility.[21] Titanium bars can be combined with PTFE or synthetic meshes, and the safety of this application has been documented.[22] Additionally, various other reconstruction materials are mentioned in the literature.[18,23]

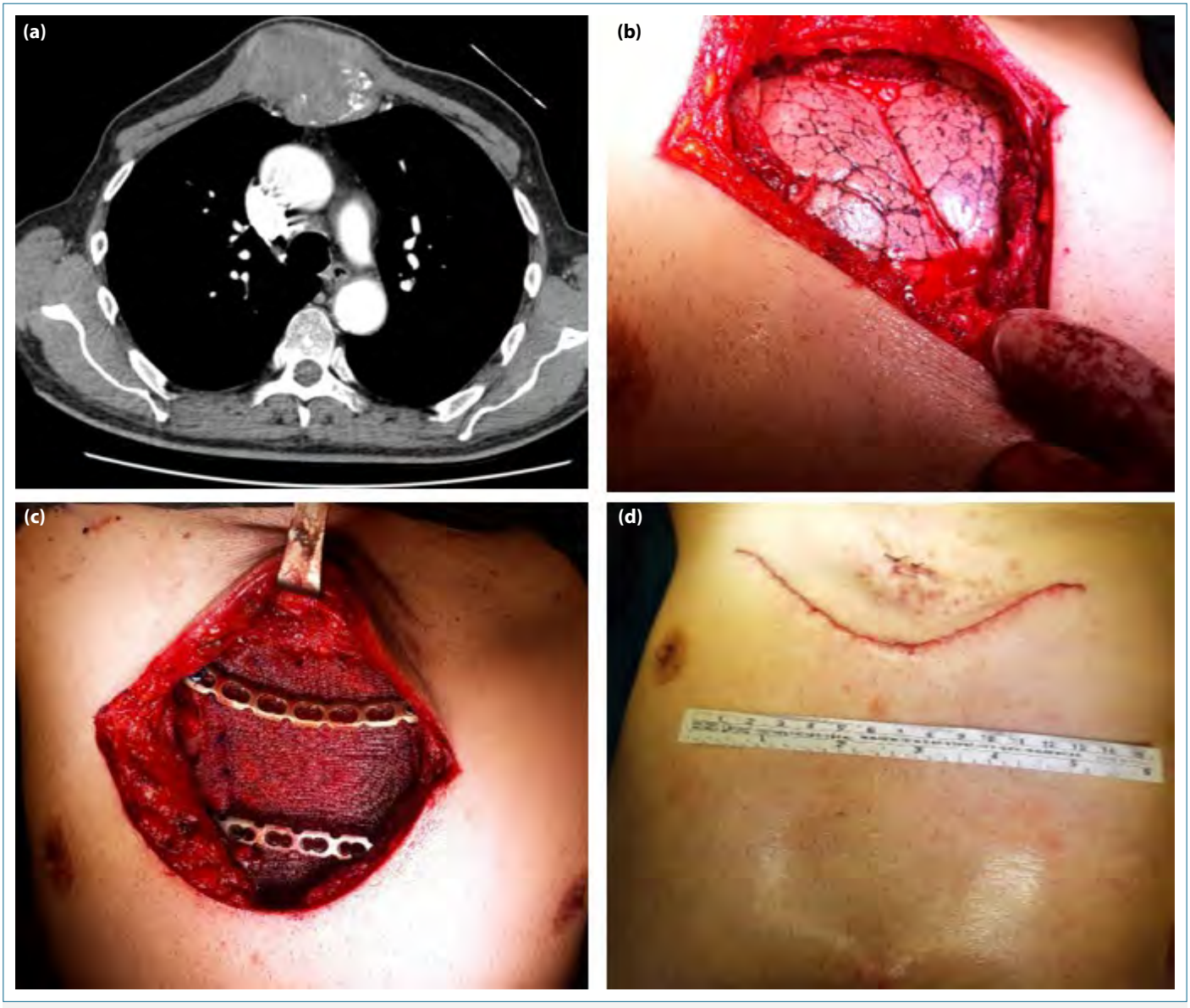

Figure 5. (a) Preoperative view of the tumor, **(b)** view after the removal of the sternum and ribs, **(c)** thoracic reconstruction using titanium and polypropylene prosthesis, **(d)** postoperative appearance.

In our study, PTFE meshes were the most frequently used option in both groups. We combine titanium bars with polypropylene or PTFE meshes in cases involving the resection of a large number of ribs or resections that include the sternum (Fig. 5). Prosthesis use varies in the literature; for instance, in King et al.'s[10] study of 90 patients, 12 required a prosthesis. The GORE-TEX Soft-Tissue Patch was chosen as a prosthetic mesh, while polypropylene and resorbable VICRYL meshes were used in another study on pediatric patients. Titanium bars were implemented in two pediatric patients who were adolescents aged 19 and 17 and had completed their growth.[8] These examples illustrate that prosthesis requirements can vary significantly for PCWTs. The choice of mesh used largely depends on the surgeon's preference or institutional policies.

Bleeding, wound site infections, and pulmonary infections are among the most frequently observed complications following chest wall surgery.[10,24] In our experience, bleeding was generally limited, but transfusion was occasionally required due to drainage from the chest tube over a few days, which can be distressing. We chose not to apply osteosynthesis in any of our pediatric patients, primarily due to concerns about growth. Furthermore,

the literature indicates that up to 44% of such plaques are dislocated or fractured.[25] A study involving eight patients found that a titanium bar had been used in two cases, one aged 6 and the other 18, with one instance of dislocation.[26] In light of these indicators and findings in the relevant literature, we do not recommend osteosynthesis, especially for prepubescent children who have not completed their development.

Ewing sarcoma and rhabdomyosarcoma are considered tumors that can be medically treated. Neoadjuvant or adjuvant treatment is suggested for these chemosensitive tumors, as their complete surgical excision is not typically possible.[21] In our study, 12 out of 23 adult patients with malignant diagnoses required chemotherapy. Our institutional policy follows the EUROpean Ewing tumor Working Initiative of National Groups Ewing Tumor Studies 1999 (EURO-E.W.I.N.G 99) protocol for ESFT, which represents the largest malignant group in the pediatric cohort of our study, significantly impacting our results. Chemotherapy was required for 45% of all pediatric patients. A study in the literature on 20 pediatric patients with Ewing sarcoma of chest wall origin found that all patients received chemotherapy.[27] Our study employed the same treatment protocols for ESFTs as those used in the study by Bedetti, where chemotherapy combined with surgery was applied to 106 out of 198 patients with non-metastatic chest wall ES tumors.[28] In summary, it can be stated that the chemotherapy requirement is subject to the malignancy rates of PCWTs and the application of new treatment protocols. Radiotherapy alone is sufficient for the treatment of solitary plasmacytoma among chest wall tumors. Thus, the role of surgery is primarily diagnostic in the treatment of solitary plasmacytoma.[11]

A statistically significant difference was not observed in our study between pediatric and adult patient groups in terms of 5-year OS rates and DFS. It was anticipated that OS and DFS would be shorter in pediatric patients compared to adults, as pediatric chest wall tumors tend to be more malignant and aggressive. Even though the difference was not statistically significant, the proportion of malignant tumors in the pediatric group was higher than that in the adult group in this study. Consequently, malignant PCWTs with impacts on the survey in both groups should be discussed. Chondrosarcomas were the most frequently observed malignant tumors in adults, with five-year survival rates varying between 64% and 92%. The second most frequently observed were solitary plasmacytoma (n=3) and malignant fibrous histiocytoma (n=3), with 5-year survival rates in the literature ranging between 40%–60% and 38%, respectively.[10,29] ESFT is the primary element of malignant PCWTs in children. Success in treating ESFT has resulted in increased OS and DFS in children, reaching rates comparable to those of adults. Previously, ESFT had very limited survival times due to the treatment protocols applied, with only 10% of patients reaching 5-year survival rates before the age of chemotherapy. Over time, multimodal treatments have been developed.[30] The expected OS and DFS rates increased dramatically following these treatments. Today, the 5-year survival rate for chest-origin non-metastatic patients has reached 65%.[27]

CONCLUSION

Considering both our study and other studies in the literature regarding PCWTs, two main limitations are evident. The first is the limited number of patients (including in our study) due to the low incidence of the disease. The second limitation is that PCWTs consist of a heterogeneous group of diseases, exhibiting different behaviors and encompassing many different tumors. These limitations decrease the reliability of the data, make subgroup analysis more challenging, and cause a wide range of data variations.

As a result, we found no difference between pediatric and adult primary chest wall tumors in terms of disease-free survival times, overall survival, and surgical complications.

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Informed Consent: Written informed consent was obtained from patients who participated in this study.

Author Contributions: Concept – ÖFD, ÖÖ; Design – AÖ, BBK; Supervision – ÖÖ, AÜ; Resource – ÖFD, AÖ; Materials – MK, BBK; Data Collection and/or Processing – ÖFD, BBK; Analysis and/or Interpretation – AÜ, AÖ; Literature Search – ÖFD, ÖÖ; Writing – AÖ, MK; Critical Reviews – ÖFD, BBK, AÜ.

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