










# Evaluation of Upper Extremity Function and Exercise Capacity after Pancoast Tumor Surgery

 Talha Doğruyol,<sup>1</sup>  Halime Sinem Barutçu,<sup>2</sup>  Selime Kahraman,<sup>1</sup>  Fatma Tuğba Özlü,<sup>1</sup>  
 Attila Özdemir,<sup>1</sup>  Berk Çimenoglu,<sup>1</sup>  Mesut Buz,<sup>1</sup>  Fatih Doğu Geyik,<sup>3</sup>  Recep Demirhan<sup>1</sup>

<sup>1</sup>Department of Thoracic Surgery, Kartal Dr. Lütfi Kırdar City Hospital, İstanbul, Türkiye  
<sup>2</sup>Department of Physiotherapy and Rehabilitation, Kartal Dr. Lütfi Kırdar City Hospital, İstanbul, Türkiye  
<sup>3</sup>Department of Anesthesiology and Reanimation, Kartal Dr. Lütfi Kırdar City Hospital, İstanbul, Türkiye

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Correspondence: Talha Doğruyol, Kartal Dr. Lütfi Kırdar Şehir Hastanesi, Göğüs Cerrahisi Kliniği, İstanbul, Türkiye  
E-mail: talhadogruyol@yahoo.com.tr



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## ABSTRACT

**Objective:** The impairment of arm functions can be observed after trimodality therapy for superior sulcus tumors due to several reasons, such as the tumor invasion of the brachial plexus and subclavian arteries, fibrosis secondary to radiotherapy, neuropathy secondary to chemotherapy, and morbidity caused by surgical resection. This study aimed to evaluate patients' arm functions and functional exercise capacities after Pancoast tumor surgery.

**Methods:** The study included patients that underwent surgery for superior sulcus tumors in our clinic after neoadjuvant therapy between April 2017 and April 2022. The patients were evaluated in terms of age, gender, pathology, neoadjuvant treatment, resection, reconstruction material used, mean hospital stay, drain withdrawal time, amount of drainage, morbidity, mortality, arm functions, and functional exercise capacities.

**Results:** Between the specified dates, 18 patients underwent surgery for Pancoast tumors in our clinic. All the patients were male. The mean age was calculated as 62.7±8.0 years. The operation was performed on the right side in 12 patients and the left in six. The most frequently performed procedure was upper lobectomy, while bilobectomy was performed in one patient. Prolonged air leak was the most common morbidity (n=5, 27.7%), but no surgical mortality was observed. Non-surgical upper extremity ranges of motion were complete, and joint limitations were found in the extremity on the surgical side at a rate varying between 28 and 78%, depending on shoulder motion. The patients' mean postoperative six-minute walk test distance was recorded as 536.6±85.7 meters.

**Conclusion:** Preserving the arm and shoulder functions of these patients has gained more importance since it increases the quality of life of these patients. Unfortunately, this study showed that the patients' arm functions were restricted, and functional exercise capacities decreased after Pancoast tumor surgery. Therefore, we recommend that intensive physiotherapy programs be planned for these patients starting from the pre-operative period.

## INTRODUCTION

The tumors of the superior sulcus, also known as Pancoast tumors, typically originate from the apex of the lung and invade the chest wall. Occasionally, these tumors may also involve the brachial plexus, vertebra, stellate ganglion, and subclavian arteries.<sup>[1]</sup> These tumors, first described by Pancoast in 1932 and still named after him, are associated with high morbidity and mortality.<sup>[2]</sup> While they were seen as inoperable and mortal tumors at the beginning, with the developments in the past 60 years, the standard surgical method has been defined as the en bloc resection of the chest wall following induction chemoradiotherapy, removal of invasive structures, and anatomical lung resection.<sup>[1,3,4]</sup>

As a surgical approach, posterior, anterior, and combined postero-anterior approaches can be preferred according to the area of involvement. For this purpose, a high posterior incision (Shaw-Paulson approach), Tatsumura approach, transclavicular (Dartevelle) approach, transmanubrial L-like incision or modified Dartevelle (Grunenwald), hemi-clamshell incision, trapdoor incision, Masaoka approach, or videothoracoscopic approach can be used.<sup>[5]</sup>

A significant improvement in survival rates has been observed in Pancoast tumors after trimodality treatment. However, the en bloc resection of the chest wall, brachial plexus, and vascular structures may affect arm and shoulder functions in the post-operative period.<sup>[1,4]</sup> It has not yet been clarified in the literature how much the quality of life

in these patients is affected by these impaired functions.<sup>[6]</sup> Impaired arm and shoulder functions result from the direct involvement of the tumor's brachial plexus or vascular structures or the neurovascular bundle compression due to the tumor's localization. Other causes of impaired arm and shoulder functions include fibrosis secondary to radiotherapy applied before or after surgery and neuropathy caused by systemic chemotherapy.<sup>[7]</sup> In the literature, only a few studies evaluate the upper extremity functions and functional exercise capacities of patients with Pancoast tumors after surgery. The current study aimed to evaluate patients' arm functions and functional exercise capacities after Pancoast tumor surgery.

## MATERIALS AND METHODS

### Patient Selection

The study included patients who underwent anatomic lung resection + chest wall resection in our clinic after neoadjuvant therapy for lung cancer between April 2017 and April 2022. Excluded from the study were cases in which chest wall resection or anatomical resection was not performed, patients with a histology other than lung carcinoma that caused Pancoast syndrome, those with N2 disease detected by invasive staging before neoadjuvant therapy, and those with progression after neoadjuvant therapy.<sup>[8,9]</sup> Preoperatively, all the patients provided informed consent for the operation. The ethics committee of Kartal Dr. Lutfi Kırdar City Hospital approved the study (number: 2021/514/216/21, date: December 29, 2021).

### Before Induction Therapy

Thoracic computed tomography (CT) was performed in all the patients in the preoperative period, and the diagnosis was made using a transthoracic fine-needle aspiration biopsy. All the patients underwent fiberoptic bronchoscopy (FOB) for endobronchial evaluation. Positron emission tomography (PET/CT) and cranial magnetic resonance imaging (MRI) were also performed in all the patients for staging and distant metastasis screening. Brachial plexus MRI was undertaken to evaluate local invasion.<sup>[10]</sup> The preferred method of induction therapy was three cycles of platinum-based chemotherapy and simultaneous radiotherapy (45–60 Gy). All the patients were re-evaluated with CT or PET/CT within the 1st month after the completion of neoadjuvant therapy. Endobronchial ultrasonography or mediastinoscopy was used in patients with suspected N2 disease after clinical staging. Surgical planning was undertaken in the patients with adequate treatment response and N2-negative cases.

### Perioperative Period

The patients' respiratory functions and cardiac conditions were evaluated in the preoperative period. Antibiotherapy was routinely administered preoperatively and postoperatively. All the patients were intubated with a double-lu-

men tube on the operating table and placed in the lateral decubitus position. For the patients scheduled to undergo mediastinoscopy, the approach was first in the supine position and frozen section, then in the lateral decubitus position. The Shaw-Paulson incision was used. Anatomical lung resection, chest wall resection, and systemic mediastinal lymph node dissection were performed.

FOB was applied on the operating table preoperatively and postoperatively for control and bronchial secretion clearance. This procedure was repeated during the post-operative period in cases where deemed necessary. All the patients were extubated on the operating table and transferred to the intensive care unit or ward depending on clinical necessity. Heart rhythm, oxygen saturation, and non-invasive systemic blood pressure parameters were monitored in the patients admitted to the wards. All the patients underwent respiratory physiotherapy in the post-operative period and were mobilized regularly. Intercostal nerve block was applied to all the patients during the postoperative period for pain control. In cases where necessary, an epidural catheter and paravertebral block were also applied for patient-controlled analgesia.

### Arm Function and Functional Exercise Capacity

The patients' arm functions and functional exercise capacities were evaluated after Pancoast tumor surgery. The arm functions of the cases were measured with a manual goniometer, and the normal range of motion was determined. Four functional shoulder movements, namely, flexion, abduction, internal rotation, and external rotation were evaluated to assess shoulder joint limitations. In cases with joint limitations, the degree of limitation was recorded. The functional exercise capacities of the cases were evaluated with the six-minute walk test (6MWT), and the walking distance was recorded in meters. For 6MWT, the guideline of the American Thoracic Society was taken as a reference.<sup>[11]</sup> The ideal 6MWT distance of the cases was calculated using their body mass index (BMI) values according to the following reference equations provided by Enright and Sherrill.<sup>[12]</sup>

Ideal 6MWT distance for men:

$$1.140 - (5.61 \times \text{BMI}) - (6.94 \times \text{age})$$

Ideal 6MWT distance for women:

$$1.017 - (6.24 \times \text{BMI}) - (5.83 \times \text{age})$$

Morbidity and mortality were evaluated for the first 30 days postoperatively using the thoracic morbidity and mortality (TM and M) classification.<sup>[13]</sup> All the patients in the study were evaluated in terms of age, gender, pathology, neoadjuvant therapy, resection, reconstruction material used, mean length of hospital stay, drain withdrawal time, amount of drainage, morbidity, and mortality. In addition, the patients' arm functions and functional exercise capacities were recorded in the post-operative period.

## Statistical Analysis

Patient demographics and collected data were entered into IBM® SPSS® (Statistical Package for the Social Sciences) version 23. Descriptive statistical methods were used. Variables were characterized as mean and standard deviation, while percentage values were used for qualitative variables.

## RESULTS

Between the specified dates, 18 patients underwent surgery for Pancoast tumors in our clinic. All the patients were male. The mean age was calculated as  $62.7 \pm 8.0$  years. All the patients had preoperatively received neoadjuvant therapy and underwent anatomical lung plus chest wall resection. Smoking history was present in all the patients. The most common comorbidities were hypertension and coronary artery disease. The patients' demographic data are given in Table 1.

Concerning neoadjuvant therapy, one patient received chemotherapy alone, one received radiotherapy alone, and the remaining 16 received neoadjuvant chemoradiotherapy. When the factors related to the operation were evaluated, the intervention was performed on the right side in 12 patients and the left in six. Concerning the type of surgery, the most common surgical procedure was lobectomy, while bilobectomy was performed in one patient. The mean number of rib resections performed was  $2.9$  (range 1–5)  $\pm 0.9$ . In addition, the T1 root was sacrificed in one patient due to brachial plexus invasion. Table 2 presents the surgical data of the patients.

**Table 1.** Patients' demographic characteristics

Variables	n (%)	Mean $\pm$ SD
Gender		
Male	18 (100.0)	
Female	0 (0.0)	
Age (years)		62.7 $\pm$ 8.0
Smoking history		
Present	18 (100.0)	
Absent	0 (0.0)	
Smoking (p/y)		47.2 $\pm$ 15.1
Comorbidity		
Hypertension	5 (27.7)	
Coronary artery disease	5 (27.7)	
Coronary bypass history	3 (16.6)	
Chronic obstructive pulmonary disease	2 (11.1)	
Corneal transplant	1 (5.5)	
Diabetes mellitus	1 (5.5)	
Atrial fibrillation	1 (5.5)	
History of tuberculosis	1 (5.5)	
Chronic lymphocytic leukemia	1 (5.5)	
Psoriasis	1 (5.5)	

p/y: Pack/year; SD: Standard deviation.

The most common morbidity was prolonged air leak (27.7%), and one patient with respiratory failure required long-term intensive care. No surgical mortality was observed. According to the TM and M classification, the cases were mostly graded II. The data on the morbidity and mortality of the patients are given in Table 3.

The patients' upper extremity joint range of motion was evaluated on both sides. Non-surgical upper extremity ranges of motion were complete, and joint limitations in the extremity on the surgical side were measured. Limited range of motion was detected in shoulder flexion in 78% of the patients, shoulder abduction in 78%, shoulder internal rotation in 50%, and shoulder external rotation in

**Table 2.** Perioperative factors

Surgical factors	n (%)	Mean $\pm$ SD
Side		
Right	12 (66.6)	
Left	6 (33.3)	
Type of surgery		
Right upper lobectomy	11 (61.1)	
Left upper lobectomy	6 (33.3)	
Superior bilobectomy	1 (5.5)	
Rib resections performed		2.9 $\pm$ 0.9
Prosthesis		
Prolene mesh	3 (16.6)	
Composite mesh	6 (33.3)	
No prosthesis	9 (50.0)	
Drainage amount (ml)		1,111.1 $\pm$ 724.2
Drain withdrawal time (days)		8.2 $\pm$ 5.5
Discharge time (days)		9.4 $\pm$ 5.3
Pathology		
Squamous cell carcinoma	14 (77.7)	
Adenocarcinoma	2 (11.1)	
Large cell neuroendocrine carcinoma	1 (5.5)	
Sarcomatoid carcinoma	1 (5.5)	

SD: Standard deviation.

**Table 3.** Post-operative morbidity and mortality

Post-operative outcomes	n (%)
Morbidity	
Prolonged air leak	5 (27.7)
Pneumonia	2 (11.1)
Flail chest	1 (5.5)
Weakness in the arm	1 (5.5)
TM and M classification	
II	3 (16.6)
IIIa	2 (11.1)
IVa	1 (5.5)
Surgical mortality	0 (0.0)

TM and M: Thoracic Morbidity and Mortality.

**Table 4.** Mean degrees of joint limitation and mean 6MWT distance of the patients

	Mean (range)
Degree of joint limitation	
Shoulder flexion	50 (0–80)
Shoulder abduction	55 (0–90)
Shoulder internal rotation	20 (0–30)
Should external rotation	10 (0–10)
Functional exercise capacity	
6MWT distance (meter)	536.6 (437–645)
Ideal 6MWT distance (meter)	573.8 (517–621)

6MWT: 6-min walk test.

28%. Degrees of joint limitations and 6MWT distances are shown in Table 4.

## DISCUSSION

In patients with Pancoast tumors, many neurological and orthopedic problems can be seen in the upper extremity related to the spread of the tumor and affected structures. Common clinical symptoms include shoulder pain due to the invasion of the parietal pleura, dorsal scapular pain due to intercostal nerve invasion, pain in the arm due to the invasion of the brachial plexus, and atrophy in the hand muscles and sensory loss depending on the dermatome area of the affected nerve.<sup>[14,15]</sup> Due to these symptoms and the absence of pulmonary symptoms in the early period, patients usually visit orthopedics or rheumatology clinics, which can delay the diagnosis of Pancoast tumors and surgical planning.<sup>[16]</sup>

It is known that the arm and shoulder functions of patients undergoing surgery for Pancoast tumors decrease despite resection or decreased compression of the vascular-nerve network. A previous study determined that the treatment performed on the dominant side of patients who received trimodality therapy for superior sulcus tumors affected the quality of life to a lesser extent than the treatment on the non-dominant side. In the same study, it was reported that although there was a slight difference in arm and shoulder functions between the treated and non-treated sides, this difference was not statistically significant.<sup>[6]</sup>

In a case series of 18 patients reported by Shahian et al.,<sup>[17]</sup> it was emphasized that shoulder functions were generally well preserved in patients who underwent Pancoast surgery after radiotherapy, but this was due to aggressive physiotherapy. In another study, it was shown that arm functions and quality of life decreased after trimodality treatment.<sup>[7]</sup> In the current study, we observed that the patients' shoulder joint range of motion was affected in the early post-operative period. Therefore, referring patients to supportive treatments, such as physical therapy during the perioperative period, is essential to improve arm and shoulder functions.

According to the data obtained from different studies, the complete resection rate of Pancoast tumors ranges from 76% to 93%, and the 5-year survival rate is over 50%.<sup>[18–23]</sup> In the literature, it has been reported that survival is positively affected by a complete resection, especially in the absence of N2 disease. The necessity of induction therapy is emphasized to achieve this.<sup>[24]</sup> This information again underlines the importance of ensuring a high quality of life after surgery and preserving arm functions as much as possible.

In the early period after lung resection, patients' functional exercise capacities decreased due to their decreased lung volumes. In addition, after Pancoast surgery, patients' mobility is partially reduced due to pain and limitation of movement in the upper extremity, which further reduces their exercise capacities. To the best of our knowledge, there are no studies evaluating patients' functional exercise capacities after Pancoast tumor surgery. The current study revealed that the patients' 6MWT distance was negatively affected, and their functional exercise capacities decreased.

## Limitations

This study included data from a single center. In addition, increased quality of life due to physiotherapy and possible tolerance to adjuvant therapy were not taken into account.

## CONCLUSION

In Pancoast tumors, decreased shoulder-arm functions and functional exercise capacities can be observed after trimodality therapy. Therefore, starting from the pre-operative period and continuing throughout the post-operative hospitalization and follow-up, it is crucial to perform physiotherapy frequently in these patients to minimize these limitations and increase their quality of life. In addition, preserving these functions can also contribute to survival by allowing patients to tolerate adjuvant therapy better. However, there is still a need for comparative studies with more extensive series to investigate this subject further.

## Ethics Committee Approval

This study approved by the Kartal Dr. Lütfi Kırdar City Hospital Clinical Research Ethics Committee (Date: 29.12.2021, Decision No: 2021/514/216/21).

## Informed Consent

Retrospective study.

## Peer-review

Externally peer-reviewed.

## Authorship Contributions

Concept: T.D.; Design: H.S.B.; Supervision: R.D., F.D.G.; Data: S.K., F.T.Ö.; Analysis: T.D., A.Ü., B.Ç., M.B.; Literature search: T.D., H.S.B.; Writing: T.D., H.S.B.; Critical revision: T.D.

## Conflict of Interest

None declared.

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## Pancoast Tümörü Cerrahisi Sonrası Üst Ekstremitte Fonksiyonlarının ve Egzersiz Kapasitesinin Değerlendirilmesi

**Amaç:** Superior sulkus tümörlerinin trimodalite tedavisi sonrası kol fonksiyonlarında bozulma gözlemlenmektedir. Bunun sebepleri brakial pleksus ve subklavyen damarların tümör tarafından invazyonu, radyoterapiye sekonder fibrozis, kemoterapiye sekonder nöropati ve cerrahi rezeksiyona bağlı morbidite olarak sayılabilir. Bu çalışmada amaç pancoast tümörü cerrahisi sonrası hastaların kol fonksiyonları ve fonksiyonel egzersiz kapasitelerini değerlendirmektir.

**Gereç ve Yöntem:** 2017 Nisan–2022 Nisan tarihleri arasında neoadjuvan tedavi sonrası kliniğimizde superior sulkus tümörü nedeniyle opere edilmiş olan hastalar çalışmaya alındı. Hastalar yaş, cinsiyet, patoloji, neoadjuvan tedavi, rezeksiyon, kullanılan rekonstrüksiyon materyali, ortalama yatış süresi, dren çekilme süresi, drenaj miktarı, morbidite, mortalite, kol fonksiyonları ve fonksiyonel egzersiz kapasiteleri bakımından değerlendirildi.

**Bulgular:** Belirtilen tarihte kliniğimizde toplamda 18 hastaya pancoast tümörü nedeniyle cerrahi uygulandı. Hastaların tamamı erkekti. Yaş ortalaması 62.7±8.0 olarak hesaplandı. On iki hastaya sağ taraftan girişim, altı hastaya sol taraftan girişim yapıldı. En sık üst lobektomi yapılırken, bir hastaya bilobektomi yapıldı. Morbidite olarak en sık uzamış hava kaçağı (n=5, %27.7) görülürken, cerrahi mortalite görülmedi. Cerrahi olmayan üst ekstremitte hareket açıklıkları tam iken, cerrahi olan taraftaki ekstremitede, omuz hareketine göre %28–78 arasında eklem limitasyonları saptandı. Hastaların postoperatif 6 dakika yürüme testi ortalaması 536.6±85.7 metre olarak kaydedildi.

**Sonuç:** Hastaların kol ve omuz fonksiyonlarının korunması, yaşam kalitelerini arttıracığından daha da önem kazanmıştır. Çalışmamızda pancoast cerrahisi sonrası kol fonksiyonlarının kısıtlandığı ve fonksiyonel egzersiz kapasitesinin düştüğü gösterilmiştir. Bu nedenle bu hastalara preoperatif dönemde itibaren başlayan yoğun fizyoterapi programları planlanması gerektiği kanaatindeyiz.

**Anahtar Sözcükler:** Akciğer kanseri; fizyoterapi; pancoast; superior sulkus; trimodalite tedavisi.