Araştırma Makalesi / Research Article

Journal of Medical Topics & Updates (Journal of MTU)

Effects of pneumothorax on patient's prognosis with COVID-19 in the intensive care unit

Pnömotoraksın COVID-19 yoğun bakım hastalarında prognoz üzerine etkisi

Nezir YILMAZ [1] Verda Dinar TUNA [2]

[1] Adıyaman Eğitim ve Araştırma Hastanesi, Anestezi ve Reanimasyon Birimi, Adıyaman, Türkiye.
[2] İstanbul Acıbadem Hastanesi, Anestezi ve Reanimasyon Birimi, İstanbul, Türkiye.

ABSTRACT

Background: In this study, it was aimed to investigate the relationship between pneumothorax (PNX) and the prognosis of COVID-19-positive patients in the intensive care unit (ICU).
Materials and Methods: File data of patients were reviewed retrospectively who received care in ICU with the diagnosis of COVID-19 between April 2020 and March 2022. Patients with and without PNX were divided into two separate groups. The obtained data from the two groups were compared, and it was tried to determine whether PNX affected mortality and prognosis.
Results: The need for mechanical ventilation (MV) (p=0.049) and MV duration (p=0.036) were found to be significantly higher in the PNX (+) group. Fio2 and PIP mean scores were significantly higher in the group with pneumothorax (p=0.000). Duration of ICU stay (p=0.003) and duration of hospital stay (p=0.015) was found to be significantly higher in the group with PNX (+).
Conclusions: The prevalence of PNX appears to be higher in patients with COVID-19 pneumonia, and it lengthens hospital stays in the ICU and raises fatality rates.

Keywords: Pneumotorax, COVID-19, Intensive Care Unit, Prognosis

ÖZET

Amaç: Bu çalışmada COVID-19 tanısı ile yoğun bakım ünitesinde takip edilen hastalarda pnömtoraksın prognoz ile ilişkisini incelemeyi amaçladık.
Materyal ve Metot: Nisan 2020 ile Mart 2022 tarihleri arasında COVID-19 tanısı ile yoğun bakım ünitesi takibindeki hastaların dosyaları retrospektif olarak incelendi. Hastalar pnömotoraks gelişen ve gelişmeyenler şeklinde iki gruba ayrıldı. Elde edilen veriler her iki grup arasında kıyaslanarak pnömotoraksın prognoz ve mortalite üzerine etkisi tespit edilmeye çalışıldı.
Bulgular: PNX (+) olan grupta MV ihtiyacı (p=0.049) ve MV süreleri (p=0.036) anlamlı olarak daha yüksek bulundu. Fio2 ve PIP ortalamaları PNX (+) olan grupta anlamlı olarak daha yüksek tespit edildi (p=0.000). PNX (+) olan grupta yoğun bakım yatış süreleri (p=0.003) ve hastane yatış süreleri (p=0.015) anlamlı daha yüksek tespit edildi.
Sonuç: Pnömotoraks COVID-19 pnömonisi olan hastalarda daha sık gözükmekte, hastane yatış süresi / yoğun bakım yatış sürelerini uzatmakta ve mortalite oranlarında artışa neden olmaktadır.

Anahtar kelimeler: Pnömotoraks, COVID-19, Yoğun Bakım Ünitesi, Prognoz

INTRODUCTION

Lung tissue is the target organ for COVID-19 infection, and in cases that cannot be managed, multi-organ failure follows. Acute Respiratory Distress Syndrome (ARDS)-supporting pathological lung findings in infected patients included cell destruction in pneumocytes, disruption of the hyaline membrane, and pulmonary edema (Xu et al., 2020).

Pneumothorax (PNX) is a common complication in ARDS patients receiving invasive or non-invasive high-pressure respiratory support. The mortality rate for these patients is affected by ARDS, which has an incidence that varies between 1.7% and 10% (Sihoe et al., 2004).

The objective of this study was to investigate the relationship between PNX and prognosis in COVID-19-positive intensive care unit (ICU) patients.

MATERIALS AND METHODS

This study was designed retrospectively and was approved by the Ethics Committee of Non-Interventional Clinical Researches of Adıyaman University (Approval no. 2022 / 4-23). The file data of the patients were reviewed retrospectively who were treated in the ICU with covid-19 between dates April 2020 and March 2022. Patients who applied to the Adyaman Training and Research Hospital with COVİD-19 symptoms or/and suspected contact history and received invasive mechanical ventilation support in the ICU due to respiratory failure were included in the study. The diagnosis of COVID-19 was established by a nasopharyngeal swab for reverse transcriptase polymerase chain reaction. Two groups of patients were established. Patients who were admitted with a clinical suspicion of having PNX were placed in the intensive care unit of the PNX (+) group. Chest radiographs and computed tomography scans confirmed their diagnosis of pneumothorax. Patients who were not clinically suspected to have PNX and whose imaging did not reveal pathology consistent with PNX comprised the PNX(-) group. The thoracic surgery clinic performed tube thoracostomies on all patients who were diagnosed with PNX and then followed them.

Patients wıth PNX(+) before hospitalization or ICU admission and patients with PNX(+) who received non-invasive mechanical ventilation support are excluded.

On the initial day of intensive care admission, all patients' demographic information, comorbidities, and laboratory results (fibrinogen, C-reactive protein (CRP), D-dimer, ferritin, and procalcitonin (PCT) utilized in the follow-up of covid-19 prognosis were recorded.

Mortality, length of ICU and hospital stay, and the necessity for and duration of mechanical ventilation (MV) were also noted. Averages of the following parameters were calculated and recorded from mechanical ventilation data: PEEP (Positive End Expiratory Pressure), Fio2 (Fraction of Inspired Oxygen), and PIP (Peak Inspiratory Pressure). The daily values for each day patients had invasive mechanical ventilation were added, and the mean value was calculated by dividing that result by the total number of days that he received invasive mechanical ventilation. The two groups' data were compared, and an attempt was made to identify how PNX affected mortality and prognosis.

Statistical method

The lowest, highest, frequency, ratio, median, mean, and standard deviation values were computed and used to define and compare statistical data. The Kolmogorov-Smirnov test was used to determine how the variables were distributed. With the independent sample t-test and Mann-Whitney U test, quantitative independent data analysis was performed. When analyzing independent qualitative data, the chi-square test was applied; however, the Fischer test was chosen when the chi-square was not available. The SPSS 28.0 program was used to conduct all analyses.

RESULTS

For this study, data from 238 patient files were obtained. There were 142 male patients and 96 female patients. PNX was detected in 30 cases. It was found that 64 patients were discharged from the intensive care unit, while 174 patients died. The demographics and characteristics of the patients are detailed in Table 1.

Table 1. Characteristics of patients.

		Min-Max			Median	Med.±sd/n-%		
Age		28.0	-	88.0	67.0	65.0	±	11.7
Sex	Female					96		40.3%
	Male					142		59.7%
Hypertension						144		60.5%
Diabetes mellitus						101		42.4%
Chronic obstructive pulmonary disease						26		10.9%
Coronary artery disease						46		19.3%
Chronic renal failure						2		0.8%
Cerebro vascular disease						14		5.9%
Fibrinogen		157.0	-	1500.0	559.0	555.3	±	178.9
C-reactive protein		0.2	-	37.6	12.1	13.8	±	7.9
Ferritin		10.4	-	5730.0	529.0	696.8	±	584.4
D-Dimer (x103)		0.1	-	92.0	1.5	3.7	±	10.3
Procalcitonin		0.0	-	86.0	0.3	1.9	±	6.9
Mechanical ventilation	(-)					48		20.2%
	(+)					190		79.8%
Pneumothorax	(+)					30		12.6%
	(-)					208		87.3%
MV duration		1.0	-	41.0	9.0	11.3	±	7.1
PEEP		0.0	-	12.0	8.0	8.2	±	2.4
FiO₂		0.0	-	100.0	80.0	77.4	±	22.0
PIP		0.0	-	35.0	25.0	24.4	±	6.4
Duration of ICU stay (day)		4.0	-	51.0	12.0	14.0	±	7.5
Duration of hospitalstay (day)		0.0	-	60.0	16.0	18.0	±	9.7
Mortality	(-)					64		26.9%
	(+)					174		73.1%

Age and gender were not significantly different between the two groups when the data were compared (p>0.05). There was no statistically significant difference in other comorbidities (p>0.05), however, HT was found to be significantly lower in the PNX(+) group (p=0.004). Fibrinogen, CRP, Ferritin, D-dimer, and PCT levels did not differ significantly (p>0.05). Patients in the PNX (+) group had significantly higher MV needs (p=0.049) and MV durations (p=0.036).

The average PEEP did not significantly differ when the MV values were compared. The PNX (+) group's average Fio2 and PIP were significantly higher (p=0.000). The length of the hospital stay (p=0.015) and ICU stay (p=0.003) were shown to be significantly longer in the PNX (+) group. Despite being greater than in the other group, the death rate in the PNX (+) group was not statistically significant. (Table 2).

Table 2. Clinical data and outcomes of patients with pneumothorax and without pneumothorax group.

		PNX (-)				PNX (+)				p	
		Med.±sd/n-%			Median	Med.±sd/n-%			Median		
Age		65.8	±	10.8	67.0	59.9	±	15.7	63.0	0.056	m
Sex	Female	85		40.9%		11		36.7%		0.661	X²
	Male	123		59.1%		19		63.3%			
Hypertension		133		63.9%		11		36.7%		0.004	X²
Diabetes mellitus		90		43.3%		11		36.7%		0.494	X²
Chronic obstructive pulmonary disease		22		10.6%		4		13.3%		0.651	X²
Coronaryartery disease		38		18.3%		8		26.7%		0.276	X²
Chronicrenal failure		1		0.5%		1		3.3%		0.237	X²
Cerebrovascular disease		13		6.3%		1		3.3%		1.000	X²
Fibrinogen		554.9	±	184.9	554.0	558.0	±	131.9	582.0	0.929	t
C-reactive protein		13.7	±	7.9	12.0	14.2	±	7.7	12.8	0.616	m
Ferritin		704.2	±	589.2	538.0	645.7	±	556.4	372.0	0.286	m
D-Dimer (x103)		3.8	±	10.6	1.5	3.0	±	8.2	1.0	0.132	m
Procalcitonin		1.8	±	7.0	0.3	2.2	±	6.4	0.4	0.618	m
Mechanical ventilation	(-)	46		22.1%		2		6.7%		0.049	X²
	(+)	162		77.9%		28		93.3%			
MV duration		10.9	±	6.9	8.0	13.6	±	8.3	12.0	0.036	m
PEEP		8.1	±	2.5	8.0	8.5	±	1.5	8.0	0.579	m
FiO₂		75.2	±	21.3	80.0	90.2	±	22.4	100.0	0.001	m
PIP		23.8	±	6.2	23.0	27.8	±	6.4	29.0	0.001	m
Duration of ICU stay (day)		13.3	±	6.9	12.0	18.3	±	10.0	16.5	0.003	m
Duration of hospitalstay (day)		17.4	±	9.1	16.0	22.5	±	12.2	20.5	0.015	m
Mortality	(-)	59		28.4%		5		16.7%		0.177	X²
	(+)	149		71.6%		25		83.3%			

t Independent sample t-test/ m Mann-whitney U test / X² Chisquare test(Fischer test)

DISCUSSION

One of the life-threatening complications is PNX, which results in lung collapse and air filling the pleural space. It is well-recognized that COVID-19 pneumonia with an ARDS-compatible image in the lungs, especially in patients on MV support, worsens this clinical pathology, which is more common in ARDS patients (Roberts et al., 2015, Akdoğan et al., 2021). One of the significant side effects of the COVID 19 illness is PNX (Martinelli et al., 2020). In the case series of covid-19 patients getting MV support, PNX and pneumomediastinum, which were classified as the clinical manifestation of barotrauma, were found to be an independent mortality factors (McGuinness et al., 2020).

Various investigations have revealed different results regarding the prevalence of PNX emerging in patients hospitalized with a diagnosis of COVID-19. In patients receiving invasive or non-invasive MV support, the incidence of PNX was 6.9% in the first wave of the coronavirus pandemic and 11.2% in the second wave, according to a study conducted by the International Severe Acute Respiratory and Emerging Infections Consortium (ISARIC) database (Marciniak et al., 2021). It was reported as 10% in Wang et al. study's of ICU patients (Wang et al., 2021). According to Chopra et a multicenter study, 13% of patients receiving MV support and 10% of ICU patients developed PNX (Chopra et al., 2021). Another multicenter study found a lower rate of

3.2% compared to previous studies and revealed that covid-19 patients in the ICU experienced it more frequently than other patients (Udwadia et al., 2021). According to this study, 12.6% of patients receiving ICU care for Covid-19 experienced PNX, which is in accordance with previous researches.

In patients receiving MV support, PNX, which causes pulmonary collapse, decreases MV values. Decreased Pao2/fio2 and static compliance were reported in PNX patients by Chopra et al (Chopra et al., 2021). There was no discernible difference in the average PEEP in patients with and without PNX in a study on PNX in intubated patients, however, considerably higher average Fio2 values were found in PNX patients (Capaccione et al., 2021). Belletti et al in their investigation, the first seven days of an intensive care hospital stay were compared for MV characteristics. The Pao2/Fio2 ratios on the third, fifth, and sixth days were found to be significantly reduced in patients who developed PNX, while there was no significant difference in 7-day PEEP values. Only hypertension was found to be statistically different across the groups when the role of comorbidities on the development of PNX was evaluated in the same study (Belletti et al., 2021). In this study, in line with the literature, there was no difference between the groups in terms of PEEP averages, although patients who developed PNX had higher Fio2 averages.

According to reports, COVID-19 patients who experience PNX had longer stays in the ICU and hospitals. According to studies, hospital stays range from 28 to 42 days, and ICU stays vary from 28 to 36 days. According to this study, the average hospital stay for covid-19 patients with PNX was 22.5 days, whereas the average ICU stay was 18.3 days. According to this study's findings, which are in line with the literature, COVID-19 patients with PNX had significantly longer hospital and ICU stays (Chopra et al., 2021; Udwadia et al., 2021; Belletti et al., 2021).

In severe COVID-19 patients with ARDS, PNX was documented as a common and fatal emergency. According to Wang et al., individuals with COVID-19 who developed PNX had an 80% death rate and a longer hospital stay than other patients (Wang et al., 2021). The mortality rate was reported as 74% in another study evaluating patients in multicenter intensive care units (Udwadia et al., 2021). In the study by Chopra et al., the mortality rate in covid-19 patients with PNX was reported at 63%. (Chopra et al., 2021).

The mortality rate in this study for ICU patients who developed PNX was 83.3%. As in other research in the literature, the detected death rate in the PNX (+) group was found to be higher than the PNX (-) group (71.6%). However, there was no significant statistical difference. It was believed that this is due to the patient population chosen for this research comprised of intubated patients in the intensive care unit with a high mortality rate, contrary to many studies where all patients diagnosed with COVID-19 patients were compared with the presence of pneumothorax. 28-day mortality was observed to be 63%-67.9% in studies with COVID-19 patients receiving invasive mechanical ventilation support. (Nishikimi et al., 2022; Yakar et al.,2021)

The study's main limitations include its retrospective and single-center design. The exclusion of patients with PNX (+) before İCU admission and patients who received non-invasive mechanical ventilation support is the other limitation of the study.

CONCLUSION

As a result, PNX seems to develop more frequently in patients with COVID-19 pneumonia, it prolongs hospital and ICU stays and raises mortality rates.

Author Contributions:

Idea/Concept: Nezir YILMAZ, Verda Dinar TUNA; **Design:** Nezir YILMAZ, Verda Dinar TUNA; **Supervision/Consulting:** Nezir YILMAZ, Verda Dinar TUNA; **Data Collection and/or Processing:** Nezir YILMAZ, Verda Dinar TUNA; **Analysis and/or Interpretation:** Nezir YILMAZ, Verda Dinar TUNA; **Literature Review :** Nezir YILMAZ, Verda Dinar TUNA; **Writing of the Article:** Nezir YILMAZ, Verda Dinar TUNA; **Critical Review:** Nezir YILMAZ, Verda Dinar TUNA;

REFERENCES

Akdogan, R.E., Mohammed, T., Syeda, A., Jiwa, N., Ibrahim, O. & Mutneja, R. (2021). Pneumothorax in mechanically ventilated patients with COVID-19 infection. Case Reports in Critical Care, 2021, 6657533.

Belletti, A., Palumbo, D., Zangrillo, A., Fominskiy, E. V., Franchini, S., Dell'Acqua, A., …& De Cobelli, F. (2021). Predictors of pneumothorax/ pneumomediastinum in mechanically ventilated COVID-19 patients. Journal of Cardiothoracic and Vascular Anesthesia, 35(12), 3642–3651.

Capaccione, K. M., 'souza, D. & Leb, B. (2021). Pneumothorax rate in intubated patients with COVID-19. Acute Crit Care, 36(1), 81–84.

Chopra, A., Al-Tarbsheh, A.H., Shah, N.J., Yaqoob, H., Hu, K., Feustel, P.J., …& Judson, M.A. (2021). Pneumothorax in critically ill patients with COVID-19 infection: Incidence, clinical characteristics and outcomes in a case control multicenter study. Respiratory Medicine, 184(106464), 106464.

Marciniak, S.J., Farrell, J., Rostron, A., Smith, I., Openshaw, P.J.M., Baillie, J.K., …& Semple, M.G. (2021). COVID-19 pneumothorax in the UK: a prospective observational study using the ISARIC WHO clinical characterisation protocol. The European Respiratory Journal: Official Journal of the European Society for Clinical Respiratory Physiology, 58(3), 2100929.

Martinelli, A. W., Ingle, T., Newman, J., Nadeem, I., Jackson, K., Lane, N. D., …& Marciniak, S.J. (2020). COVID-19 and pneumothorax: a multicentre retrospective case series. The European Respiratory Journal: Official Journal of the European Society for Clinical Respiratory Physiology, 56(5), 2002697.

McGuinness, G., Zhan, C., Rosenberg, N., Azour, L., Wickstrom, M., Mason, D.M., … Moore, W.H. (2020). Increased incidence of barotrauma in patients with COVID-19 on invasive mechanical ventilation. Radiology, 297(2), E252–E262.

Nishikimi, M., Jafari, D., Singh, N., Shinozaki, K., Sison, C. P., Shoaib, M. & Becker, L. B. (2022). Northwell health COVID-19 research consortium.

mortality of mechanically ventilated COVID-19 patients in traditional versus expanded intensive care units (Vol. 19). New York: Ann Am Thorac Soc, 19(8), 1346-1354.

Roberts, D.J., Leigh-Smith, S., Faris, P.D., Blackmore, C., Ball, C. G., Robertson, H.L., …& Stelfox, H.T. (2015). Clinical presentation of patients with tension pneumothorax: A systematic review. Annals of Surgery, 261(6), 1068–1078.

Sihoe, A.D., Wong, R.H. & Lee, A.T. (2004). Severe acute respiratory syndrome complicated by spontaneous pneumothorax. Chest, 125(6), 2345–2351.

Udwadia, Z.F., Toraskar, K.K., Pinto, L., Mullerpatan, J., Wagh, H. D., Mascarenhas, J. M.… & Gupta, G.A. (2021). Increased frequency of pneumothorax and pneumomediastinum in COVID-19 patients admitted in the ICU: A multicentre study from Mumbai, India. Clinical Medicine (London, England), 21(6), e615–e619.

Wang, X.-H., Duan, J., Han, X., Liu, X., Zhou, J., Wang, X. …& Guo, S. (2021). High incidence and mortality of pneumothorax in critically Ill patients with COVID-19. Heart & Lung: The Journal of Critical Care, 50(1), 37–43.

Xu, Z., Shi, L., Wang, Y., Zhang, J., Huang, L., Zhang, C. & Wang, F.-S. (2020). Pathological findings of COVID-19 associated with acute respiratory distress syndrome. The Lancet. Respiratory Medicine, 8(4), 420–422.

Yakar, M.N., Ergan, B., Ergün, B., Küçük, M., Cantürk, A., Ergon, M.C. …& Gökmen, A.N. (2021). Clinical characteristics and risk factors for 28-day mortality in critically ill patients with COVID-19: a retrospective cohort study. Turkish Journal of Medical Sciences, 51(5), 2285–2295.