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Intraoperative Lung Mechanics in Post-Covid Healthy Pregnants Who Required Cesarean Section: An Observational Study

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ABSTRACT

Objective: This study aimed to investigate whether lung mechanics were affected in patients recovering from Covid-19 without ARDS (Acute Respiratory Distress Syndrome) who did not undergo lung imaging during the active infection period.

Methods: Patients who underwent cesarean section under general anaesthesia were included in the study. The study included 100 patients divided into two groups: those who had recovered from Covid-19 within the last year (group 1, n=50) and those who had never experienced Covid-19 infection (group 2, n=50). Peak pressure (Ppeak), plateau pressure (Pplato), dynamic compliance (Cdyn), and positive end-expiratory pressure (PEEP) values, measured by the anesthesia machine, were recorded at specified time intervals following intubation.

Results: Comparisons of Ppeak, Pplato, ΔP (Driver pressure), Cdyn, and R (Airway resistance) data at specified times (1 min, 5 min, 10 min, 20 min, 30 min, and 40 min) showed no significant differences between the groups (p>0.05).

Conclusion: During the cesarean section, no significant differences in lung mechanics were found between the COVID-19-recovered pregnant group and those who had never experienced COVID-19 infection.

Keywords: *Covid-19, Cesarean section, Respiratory mechanics*

Sezaryen Gerekli Post-Covid Sağlıklı Gebelerde İntraoperatif Akciğer Mekanikleri: Gözlemsel Bir Çalışma

Araştırma Makalesi

Süreç

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ÖZET

Amaç: Bu çalışmanın amacı aktif enfeksiyon süresi boyunca akciğer görüntüleme yapılmamış ve ARDS (Akut Respiratuar Distres Sendromu) olmadan Covid-19'dan iyileşen hastalarda akciğer mekaniklerinin etkilenip etkilenmediğini göstermektir.

Yöntem: Genel anestezi altında sezaryen yapılan hastalar çalışmaya dahil edilmiştir. Çalışmaya alınan 100 hasta iki gruba ayrıldı: Son 1 yıl içinde Covid-19 enfeksiyonu geçirip iyileşmiş hastalar (grup 1, n:50) ve kontrol grubu olarak hiç Covid-19 enfeksiyonu geçirmemiş hastalar (grup 2 n:50). Genel anestezi altında opere olan hastalarda MAP (ortalama arteryal basınç), HR (kalp hızı) ve SpO_2 (oksijen satürasyonu) değerleri hasta takip formunda belirli zamanlarda ölçüldü ve kaydedildi. Entübasyon sonrası 1.dakikadan itibaren belirtilen zaman aralıklarında anestezi makinesi tarafından ölçülen tepe basıncı (Ppeak), plato basıncı (Pplato), dinamik kompliyans (C_{dyn}) ve ekspirasyon sonu pozitif basınç (PEEP) değerleri kaydedildi.

Bulgular: Her iki gruptaki bireylerden belirli zamanlarda elde edilen Ppeak, Pplato, ΔP (sürücü basıncı), C_{dyn} ve R (havayolu direnci) verileri karşılaştırıldığında gruplar arası anlamlı fark bulunmamıştır. Grup 1 ve Grup 2'ye ait farklı zamanlarda elde edilen Pplato, ΔP ve R ölçümleri istatistiksel olarak anlamsız bulunmuştur.

Sonuç: Sezaryen sırasında, COVID-19'dan kurtulan gebe grubu ile COVID-19 enfeksiyonunu hiç yaşamamış olanlar arasında akciğer mekanikleri açısından önemli bir fark bulunmamıştır.

Anahtar Kelimeler: *Covid-19, Sezaryen, Akciğer mekanikleri*

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Introduction

Lung mechanics refers to lung function as measured by changes in pressure and flow. These measurements encompass static compliance, airway resistance, plateau pressure and driving pressure.[1]

Compliance signifies the change in volume per unit pressure change and is indicative of alveolar expansibility; higher compliance values correlate with greater alveolar distensibility.[2] Airway resistance measures the pressure required to generate 1 liter/minute of gas flow through the airways, increasing as airway diameter decreases, thereby reflecting the degree of airway obstruction.[3] The ratio of the difference between peak inspiratory pressure and plateau pressure to flow determines resistance.[1] ΔP, or driving pressure, represents the difference between plateau pressure and PEEP, with ΔP <15 cmH2O recommended as safe;[4] lower driving pressure correlates with reduced risk of ventilator-induced lung injury.[5] Plateau pressure is measured in the absence of gas flow and indicates the pressure needed to maintain tidal volume in the lungs.[6]

Cdyn decreases due to conditions such as airway or endotracheal tube obstruction caused by secretions, bronchospasm, or tube kinking.[7] However, pregnancy has no impact on dynamic compliance.[8,9]

Several studies have explored the impact of Covid-19 infection on lung mechanics, particularly in Covid-19-associated ARDS (CARDS) patients, demonstrating significant lung impairment in cases with evident lung involvement.[10–12] Pulmonary mechanics were found to be affected in these patients with lung involvement. This requires clarification of two issues that have not yet been studied: The possible effects on lung mechanics in non-ARDS patients in whom lung involvement cannot be visualized by any imaging modality and in patients who have recovered from the infection.

This study was conducted during cesarean section procedures in pregnant patients. Its objective was to investigate whether lung mechanics were affected in patients recovering from Covid-19 without ARDS who did not undergo lung imaging during the active infection period.

Material and Methods

This observational study enrolled pregnant females classified as American Society of Anesthesiologists (ASA) II who had recovered from Covid-19 between October 2021 and October 2022, alongside ASA II pregnant females without prior Covid-19 infection. Informed consent was obtained from all participants. The study received Sivas Cumhuriyet University Clinical Research Ethics Committee approval on 28.09.2021 (Decision No. 2021-09/03). The study followed the principles of the Declaration of Helsinki.

The present study included patients with chronic lung disease such as chronic obstructive pulmonary disease, asthma, interstitial lung disease, hypertension, pulmonary hypertension, lower or upper respiratory tract infection, history of lung surgery, single lung, beta 2 agonists, patients using bronchodilators such as anticholinergics and theophylline or inhaled/oral corticosteroids, patients using drugs that cause bronchospasm such as beta-blockers, patients with unstable hemodynamics; patients whose consent for the study could not be obtained or who refused to participate in the study were excluded from the study. Patients with unstable hemodynamics, intraoperative hemodynamic instability, or requiring endotracheal tube exchange were excluded.

The 100 patients included in the study were divided into two groups: Patients who had Covid-19 infection in the last 1 year and recovered (group 1, n:50) and patients who had never had Covid-19 infection as the control group (group 2 n:50).

Preoperatively, MAP, HR, and SpO2 were recorded, and standard 5-lead electrocardiography monitoring was performed in the operating room. Intravenous (i.v.) NaCl 0.9% infusion of 10 ml/kg/h in the first hour and 5 ml/kg/h thereafter was started and preoxygenation was administered with 100% oxygen for 3-5 minutes.

All patients underwent standard general anesthesia protocol. Under this standard general anesthesia protocol, 4-6 mg/kg thiopental sodium i.v. and 0.5 mg/kg rocuronium i.v. were administered. Patients were intubated with an appropriate endotracheal tube after adequate depth of anesthesia and ventilation with a mask was achieved. Subsequent to endotracheal intubation, routine mechanical ventilator settings were as follows: tidal volume: 6 mL/kg, respiratory frequency: 12/min, PEEP: 5 cmH_20, fresh gas flow: 3 L/min, gas setting: 2% sevoflurane in a mixture of 50% air and 50% oxygen. After clamping the umbilical cord, 1µg/kg fentanyl was administered to the mother.

MAP, HR and SpO_2 values were documented preop (before induction) and at the time of induction in the patient follow-up form in patients operated under general anesthesia. The same values were measured and documented at 1 minute, 5 minutes, 10 minutes, 20 minutes, 30 minutes, 40 minutes, 50 minutes, 60 minutes after intubation. Ppeak, Pplato, C_{dyn} and PEEP values measured by the anesthesia machine (GE Healthcare brand, Carestation 620) were documented at specified time intervals starting from the 1st minute after intubation. ΔP and R values, which were the other data compared between the groups, were calculated, and documented for certain time intervals with the formulas mentioned below.

ΔP = Pplato – PEEP

Flow rate= Tidal Volume / Inspiration time

R= Ppeak-Pplato/ Flow rate (cmH_20/L/sec)

Statistical analysis

The study aimed for a power of 0.80 with α=0.05, considering d=0.60, and included 50 patients in each group (patient and control groups, respectively). A total of 100 people were included in the study. The data obtained from our study were analyzed using the SPSS (version 22.0) software package. When the assumptions for parametric tests were met (Kolmogorov-Smirnov test), the significance of the difference between two means was used to compare measurements obtained from two independent groups. When the assumptions for parametric tests were not met, the Mann-Whitney U test was used for comparisons between two independent groups. The Chi-square test was employed for the evaluation of categorical data. The data are

presented in tables as arithmetic mean and standard deviation, with an alpha level of 0.05 considered for statistical significance.

Results

The mean age of patients was 30.77±6.39 years in Group 1 and 30.22±5.38 years in Group 2 (p>0.05).

In terms of smoking status, 46 patients in Group 1 and 49 patients in Group 2 were smokers (p>0.05). Additionally, no statistically significant differences were observed between the two groups regarding body mass index (BMI) and gestational week (p>0.05).

The mean duration of COVID-19 infection in Group 1 patients was 7.91±4.33 months. A total of 27 patients were asymptomatic, 23 experienced mild symptoms such as fever, joint pain, runny nose, and weakness, while 5 patients required hospitalization; none had a history of intensive care unit admission.

No significant differences were observed between the groups when comparing HR, MAP and SpO2 values at specified times (preoperative, post-induction, 1 min, 5 min, 10 min, 20 min, 30 min, and 40 min) (p>0.05).

Similarly, when comparing Ppeak, Pplato, ΔP, Cdyn, and R data obtained from patients at specific times (1 min, 5 min, 10 min, 20 min, 30 min, and 40 min), no significant differences were found between the groups (p>0.05).

Intra-group comparisons of measurements at specified times for Group 1 and Group 2 revealed significant decreases in HR and MAP measurements towards the end of the operation in both groups.

No statistically significant differences were found in Pplato, ΔP, and R measurements at different times within Group 1 and Group 2 (p>0.05).

However, the increase in Cdyn values towards the end of surgery was found to be statistically significant in both groups (p<0.05).

Differences in SpO2, MAP, and Cdyn values observed during the study were attributed to routine anesthesia procedures such as laryngoscopy, endotracheal intubation, and PEEP application. Further comprehensive studies involving larger patient cohorts are recommended to explore the long-term pulmonary implications of Covid-19 infection in recovering patients.

***Table 1**. Statistical data for comparison of HR, MAP and SpO2 values between groups*

	Grup 1			Grup 2		
	Mean ± SD			Mean ± SD		
	HR	MAP	spO2	HR	MAP	spO2
Preoperation	95.52±15.51	92.56±10.70	97.15±1.22	94.42±16.77	97.38±16.56	97.02±1.20
Induction	111.24±19.84	95.28±12.26	98.31±1.54	104.7±18.59	99.74±17.98	98.22±1.20
1st min.	113.68±23.17	101.78±15.45	98.78±1.09	114.48±17.74	105,7±21.29	98.76±1.02
5th min.	106.91±14.51	93.52±17.90	98.63±1.07	106.3±16.77	100.28±18.04	98.46±0.93
10th min.	103.42±13.98	85.98±11.79	98.61±1.16	100.4±17.10	90,7±14.44	98.6±0.75
20th min.	101.16±18.16	81.63±12	98.63±1.06	100±15.70	87.68±13.64	98.46±0.93
30th min.	100.79±11.68	82.2±9.12	98.65±1.20	99.91±17.83	89.33±21.02	98.44±0.82
40th min.	98±10.13	82.66±7.84	98.33±1.03	98.6±21.43	97.4±17.54	98.4±0.54

HR:Heart Rate, MAP:Mean Arterial Pressure, SpO_2:Peripheral Oxygen Saturation, min.:Minute

***Table 2.** Statistical data for comparison of Ppeak, Pplato, ΔP, Cdyn and R values between groups*

	Grup 1					Grup 2				
	Mean ± SD					Mean ± SD				
	Ppeak	Pplato	ΔP	Cdyn	R	Ppeak	Pplato	ΔP	Cdyn	R
1st min.	18.1±2.62	15.71±2.75	10.71±2.78	37.62±7.98	9.1±10.29	18.92±3.77	16.72±3.60	11.78±3.59	36.75±8.37	7.1±4.25
5th min.	17.17±2.33	15.08±2.64	10.12±2.71	40.28±7.81	7±4.67	18.44±3.25	16.26±3.28	11.34±3.31	37.36±8.57	7.25±3.50
10th min.	17.26±2.43	15.08±2.74	10.15±2.76	40.19±7.90	7.24±4.98	17.84±2.89	15.76±3.06	10.78±3.07	39.26±7.77	6.88±3.70
20th min.	17.14±2.18	15.1±2.43	10.12±2.40	40.15±6.83	6.81±4.19	17.62±2.60	15.68±3.01	10.72±2.86	39.75±7.04	6.31±3.20
30th min.	17.68±2.56	15.68±2.72	10.68±2.72	38.73±7.62	6.59±4.95	18.2±3.09	16.29±2.74	11.2±2.70	39.3±7.90	7.86±6.40
40th min.	18±1.67	17±1.67	12±1.67	37.08±3.14	3.36±0.25	17.4±2.70	16±2.12	11±2.12	40.32±9.67	4.66±2.93

Ppeak: Peak pressure, Pplato: plateau pressure, ΔP: Cdyn: dynamic compliance, R: airway resistance, min.:minute

***Table 3.** Statistical evaluation of MAP and HR values measured at different times within the groups*

	Grup 1		Grup 2	
	Mean±SD		Mean±SD	
	HR	MAP	HR	MAP
Preoperation	107.93±18.20	91.1±10.39	105.25±19.85	105.29±19
Induction	96.6±14.11	93.93±11.34	93.54±16.79	108.58±19.49
1st min.	113.72±15.60	100.44±15.40	114.2±20.08	115.25±19.70
5th min.	105.89±10.29	92.93±22.14	108.7±18.89	104.37±20.26
10th min.	100.65±11.13	85.68±12.06	101.83±21.03	94.04±17.73
20th min.	98.03±19.29	78.89±8.66	101.54±17.87	92.87±15.24
30th min.	100.79±11.68	82.2±9.12	99.91±17.83	89.33±21.02
	p=0001	p=0.001	p=0.001	p=0.001

HR:Heart Rate, MAP:Mean Arterial Pressure, min.:Minute

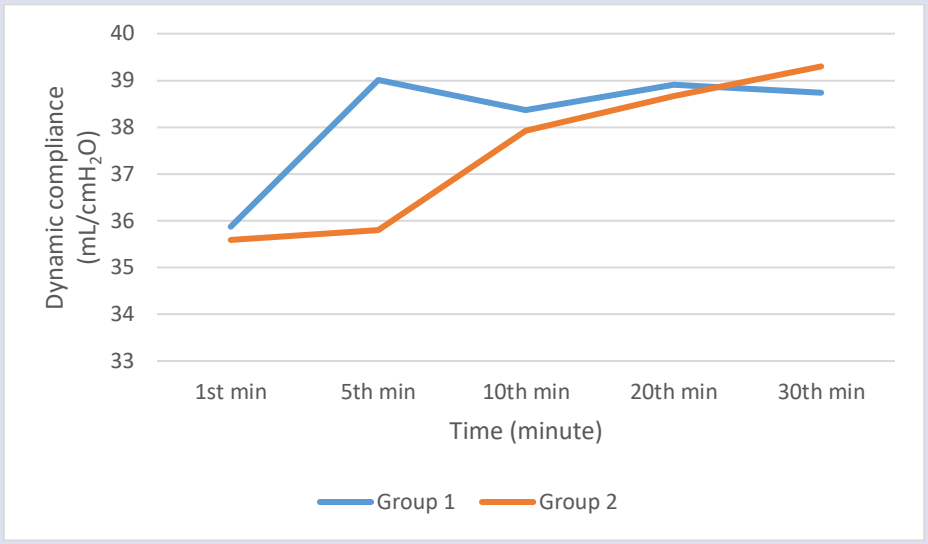

Figure 1: The change in Cdyn. values during the surgery

Discussion

The study results indicated no significant difference in intraoperative lung mechanics among patients who had recovered from COVID-19. Cdyn values increased in both patient groups later in the operation. The significant difference in HR, MAP, and SpO2 measurements was interpreted as elevations secondary to intubation.

It is known that static and dynamic lung compliance and inspiratory muscle strength are not affected by pregnancy.[8] Therefore, these data will not present any differences in the patients in our study due to pregnancy.

Although there are a few studies in the literature investigating the effects of infection on lung mechanics in COVID-19-associated ARDS cases, studies on lung mechanics in patients with COVID-19 and recovered surgery are limited. Since the first definition of ARDS in 1967, extensive studies have shown that the underlying lung injury may be due to a variety of physiological changes, including alveolar collapse, decreased lung compliance, increased pulmonary vascular resistance, and impaired gas exchange.[13] Ferrando et al. studied parameters such as Pplato, ΔP, and lung compliance in mild, moderate, and severe CARDS patients. The study revealed that Pplato values were significantly lower in patients with mild ARDS, whereas no difference was found between the other data. The same study also found that respiratory parameters (compliance, Pplato, ΔP) of CARDS patients and non-COVID However, it was reported following the study that lung compliance may vary in COVID-19 patients. L and F phenotypes were identified in COVID-19 patients accordingly.[14] Based on these findings, Puah et al. studied phenotype and mortality. COVID-19 patients admitted to intensive care were divided into two groups: patients with low and high complexity. They reported that there was no difference in oxygenation at baseline in the two patient groups after intubation, but Pplato and ΔP were higher in the patient group with low compliance. There was no significant change in the lung compliance values of patients with low compliance at baseline on day 7. However, patients initially classified as having high compliance had a significant reduction in lung compliance. The researchers reported that mortality was also significantly higher in patients in the high-complexity group compared to the low-complexity group at baseline.[12] However, a different result was obtained from the study by Yıldırım et al. In their study on lung mechanics in mechanically ventilated CARDS patients, Pplato and ΔP were significantly higher in deceased patients, while lung compliance data were significantly lower. When the patients were divided into two groups with drive pressure below and above 15 cmH2O, the mortality rate on day 28 was lower in the group with drive pressure below 15 cmH2O.[15] However, the study by Puah et al. showed that the lung compliance of patients with initially high compliance rapidly decreased and mortality rates of patients in this group were found to be high. In fact, the mortality rates of patients with low lung compliance in the study by Yildirim et al. were also high.

The positive effect of low ΔP values on mortality in ARDS patients is established.[16] It is critical whether the same is also applicable to CARDS patients followed up in intensive care. Boscolo et al. sought to answer this question and found a direct relationship between ΔP and mortality. Increasing ΔP from 10 cmH2O to 14 cmH2O in CARDS patients resulted in significantly increased mortality rates in the intensive care unit.[17] It was also reported that intraoperative low ΔP values were associated with decreased postoperative respiratory complications in patients followed.[18] The reason for the high ΔP in ARDS patients is that the lung volume participating in respiration, i.e., the functional lung volume, is reduced. Likewise, lung pathologies such as atelectasis, consolidation, bullae, effusion, fibrosis, barotrauma, or atelectotrauma are associated with increased ΔP. The present study, in which we investigated the possible pulmonary effects of COVID-19 in patients who recovered from COVID-19 without ARDS and in whom lung imaging could not be performed, showed no difference in ΔP values between the two groups, suggesting that patients recovered completely without any lung pathology.

When the measurements obtained at different times of the groups were compared among themselves, MAP and HR measurements of both groups were found to be higher in the first minutes of the operation compared to the later measurements, and this difference was found to be statistically significant. This is explained by the increase in MAP-HR measurements as a sympathoadrenergic response to endotracheal intubation and the suppression of this response after cord clamping and i.v. opioid administration.

When SpO2 measurements obtained at different times in participants with and without COVID-19 were analyzed, all SpO2 measurements obtained after induction in both groups were found to be higher than the pre-induction measurements, and this difference was found to be statistically significant. This difference may be attributed to insufflation with 100% FiO2 at the beginning of induction and intubation and positive pressure ventilation with 50% FiO2 values afterward.

Cdyn values measured at different time intervals in patients with and without COVID-19 were found to be increased in the later stages of surgery compared to the beginning. There was a significant difference in both groups. Decreasing Ppeak values later in the operation account for increasing compliance. It was also stated in the review published by Öz et al. that the application of continuous positive airway pressure and PEEP will increase lung compliance.[19] With the data available on Cdyn, we conclude that lung compliance increases in the later stages of the operation, regardless of COVID-19 history.

All of these studies report changes in lung mechanics seen in CARDS patients. The present study focused on the lung mechanics of patients who had COVID-19 without ARDS. These patients were also patients who had not undergone lung imaging during their active disease.

Limitations

This study has several limitations. Since the patients were pregnant, lung imaging was not performed. We endeavored to investigate whether the lungs of these patients were affected. The extent of lung involvement remains unknown. Additionally, there are no other studies in the literature investigating the intraoperative respiratory mechanics of patients who have had COVID-19. Studies related to respiratory mechanics are generally conducted on patients with CARDS.

Conclusions

Covid-19 has known or unknown effects on systems other than the respiratory system. We attempted to reveal possible respiratory system effects by studying intraoperative lung mechanics in patients who had the disease and could not undergo lung imaging. This study was conducted during cesarean surgeries in pregnant patients. The findings indicate no significant differences in lung mechanics between the Covid-19-recovered patient group and the control group.

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