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Polysomnography in normocapnic patients receiving domiciliary non-invasive mechanical ventilation due to chronic respiratory failure: is it really necessary?

Kronik solunum yetmezliği nedeniyle evde non-invaziv mekanik ventilasyon kullanan normokapnik hastalarda polisomnografi: gerçekten gerekli mi?

Gülgün Çetintaş Afşar, Eylem Tunçay

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Abstract

Purpose: Sleep affects respiratory system and lung mechanisms in patients with respiratory diseases, thus hypercapnia and hypoxemia could be determined during sleep. Nowadays the usage of domicilary non-invasive mechanical ventilation (NIV) have increased due to chronic respiratory failure (CRF). There is limited data about the polysomnographic features of the CRF patients requiring domiciliary NIV. The aim of this study was to evaluate the polysomnographic features of the domiciliary NIV patients.

Material and methods: This retrospective, cross sectional study was conducted in sleep laboratory between January 2016-2019. Patients who underwent polysomnography were evaluated and using domiciliary NIV were included. Patient characteristics, diagnosis, comorbid diseases, polysomnographic parameters, NIV usuage hours, spirometry values, length of ICU stay were recorded. Appropriate statistical tests and analyzes were used.

Results: Among 1850 patients who underwent polysomnography between January 2017-2019, thirty-four patients who were followed-up by domiciliary NIV were included. 22 (64.7%) of the cases were female, mean age was 67±10 years and 82.4% were diagnosed COPD. Total sleep time was 347.2±61.5 minutes and sleep efficiency was 68±13%. N1, N2, N3 and REM sleep percentage of total sleep time was 5.5 (4.6-8), 62.6 (59-69), 19.7 (13-27), 7.9 (5-13.5) respectively. NIV usage hours in ICU and out-patient clinic were7 (6-8), 3.3 (2.1-4.4) hours respectively.

Conclusion: Abnormal sleep architecture and sleep related abnormalities can be seen in patients with CRF using domicilary NIV. In normocapnic CRF patients with domiciliary NIV, who has low compliance to devices, polysomnography should be performed to evaluate sleep features and the effect of NIV device on sleep.

Key words: Polysomnography, domiciliary non-invasive mechanical ventilation, Sleep apnea, chronic respiratory failure.

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Özet

Amaç: Uyku, solunum yolu hastalıkları olan hastalarda solunum sistemini ve akciğer mekanizmalarını etkiler, uyku sırasında hiperkapni ve hipoksemi gelişebilir. Günümüzde evde non-invaziv ventilasyonun (NIV) kullanımı kronik solunum yetmezliğe (KSY) bağlı olarak artmıştır. Evde NIV kullanan hastaların polisomnografik özellikleri ile ilgili veriler kısıtlıdır. Bu çalışmanın amacı, evde NIV kullanan hastalarının polisomnografik özelliklerini değerlendirmektir.

Gereç ve yöntem: Bu retrospektif, kesitsel çalışma, Ocak 2016-2019 tarihleri arasında uyku laboratuvarında gerçekleştirilmiştir. Uyku laboratuvarında polisomnografi yapılan hastalar içinde KSY'ye bağlı evde NIV kullanan hastalar çalışmaya dahil edildi. Hasta özellikleri, tanı, komorbid hastalıklar, polisomnografik parametreler, evde NIV kullanım saatleri, spirometri değerleri, yoğun bakım kalış süresi kaydedildi. Uygun istatistiksel testler ve analizler kullanıldı.

Bulgular: Çalışmaya Ocak 2017-2019 yılları arasında polisomnografi yapılan 1850 hasta arasında, KSY nedeniyle evde NIV kullanan otuz dört hasta dahil edildi. Olguların 22'si (%64,7) kadındı, yaş ortalaması 67±10 idi ve % 82,4'üne KOAH tanısı mevcuttu. Toplam uyku süresi 347,2±61,5 dakika ve uyku etkinliği %68±13 idi. Toplam uyku süresinin N1, N2, N3 ve REM uyku yüzdeleri sırasıyla 5,5 (4,6-8), 62,6 (59-69), 19,7 (13-27), 7,9 (5-13,5) idi. Yoğun bakım ünitesinde yatışları esnasında NIV kullanımı 7 (6-8) saat, evde 3,3 (2,1-4,4) saat idi.

Sonuç: Evde NIV kullanan KSY hastalarında anormal uyku yapısında anormallikler görülebilir. Normokapnik KSY hastalarında evde NIV cihaz uyumu az olan hastaların, uyku özelliklerini ve NIV cihazının uyku üzerindeki etkisini değerlendirmek için polisomnografi yapılmalıdır.

Gülgün Çetintaş Afşar, MD. Department of Pulmonary Diseases, Health Sciences University, Sureyyapasa Pulmonary Disease and Pulmonary Surgery Training and Research Hospital, ISTANBUL, e-mail: gulguncet@hotmail.com (orcid.org/0000-0002-8686-3346) (Responsible Author)

Eylem Tunçay, Uzm. Dr. Department of Pulmonary Diseases, Health Sciences University, Sureyyapasa Pulmonary Disease and Pulmonary Surgery Training and Research Hospital, ISTANBUL, e-mail: acarturkeylem@yahoo.com (orcid.org/0000-0002-5046-1943)

Anahtar kelimeler: Polisomnografi, evde noninvaziv ventilasyon, uyku apne, kronik solunum yetmezliği.

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Introduction

Sleep is a global state with unclear functions and significant changes in the respiratory system occur during sleep [1]. Sleep has effect on breathing, via central respiratory control, lung mechanics, respiratory muscle contractility and also causes hypercapnia, hypoxemia in REM sleep, especially in Chronic Obstructive Pulmonary Disease (COPD) patients [2].

Over the past decade, domiciliary use and indications of non-invasive mechanical ventilation (NIV) have increased due to chronic respiratory failure [3]. NIV is usually applied during sleep and its usage at home recently increases. When the group of patients with chronic respiratory failure (CRF) using domiciliary NIV were examined; majority of the cases were COPD, followed by neuromuscular diseases, chest wall diseases and obesity hypoventilation syndrome [4].

In recent studies, improvement in respiratory mechanics, hypercapnia and hypoxemia, improved sleep quality and quality of life, increased benefit from pulmonary rehabilitation was shown in patients receiving domiciliary NIV treatment [5-8]. However, there is not adequate data about the polysomnographic features of the normocapnic CRF patients requiring domiciliary NIV [9].

The aim of this study was to evaluate the polysomnographic features of normocapnic domiciliary NIV patients. During the long term follow-up of the normocapnic CRF patients', we thought that polysomnographic features may help the clinicians in daily practice, with regard to device cessation and the type of NIV device together with clinical and laboratory findings.

Methods

This retrospective, observational, cross sectional study was conducted in a tertiary teaching hospital for chest diseases and thoracic surgery center, Sleep Laboratory between January 2016-2019.

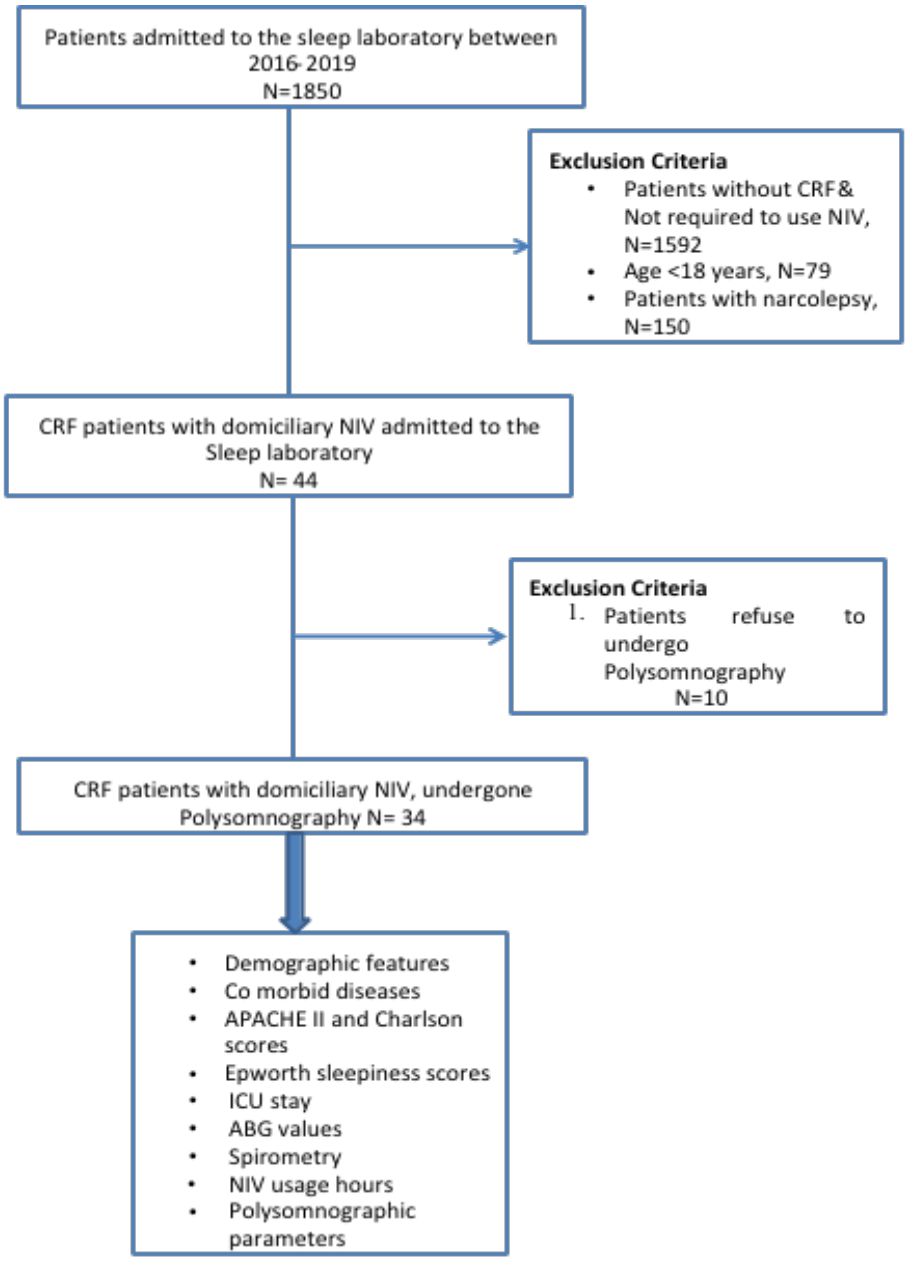
The Univercity of Health Sciences Süreyyapaşa Chest Diseaes and Chest Surgery Training Hospital local ethics committee approved the study (number/date, 077/21.08.2019) and it was in accordance with the Declaration of Helsinki. Due to the retrospective nature of the study design, informed consent from patients to review their medical records was not obtained, patient data was de-identified.

Patients

Between 2017 and 2019, patients who underwent polysomnography in our sleep laboratory were retrospectively evaluated. Patients who were referred to sleep disorders clinic from chronic respiratory failure outpatient clinic were examined. The 'chronic respiratory failure outpatient clinic' was designed for patients receiving long-term oxygen therapy (LTOT), non-invasive mechanical ventilation (NIV) and invasive mechanical ventilation (IMV), for osbtructive and restrictive lung diseases such as kyphoscoliosis, obesity hypoventilation, obstructive sleep apnea, neuromuscular diseases, bronchiectasis, COPD, asthma, tuberculosis sequelae and tracheostomized patients. One, three and six-month follow-ups were performed after discharge from ICU.

Obstructive lung disease was defined according to pulmonary function test as if forced expiratory volume in 1 second (FEV1) /forced vital capacity (FVC) was equal or less than 70%. If FEV_1/FVC was less than 70% , it was accepted as restrictive lung diseases [10].

Patients using domiciliary NIV due to CRF and had undergone Polysomnography test was evaluated and included to the present study. The flowchart of the study was summarized in Figure 1.



CRF, Chronic respiratory failure; NIV, non-invasive mechanical ventilation; APACHE II, acute physiology and chronic health evaluation; ICU, intensive care unit; ABG, arterial blood gase.

Figure 1. Flow Chart of the study.

Definition of Chronic Respiratory failure

According to arterial blood gas values, chronic hypercapnic and hypoxemic respiratory failure; was defined as pH above 7.45 and PaCO2 above 45mmHg and PaO2 below 55mmHg if patients were in clinically stable state [11, 12].

Reasons for Domiciliary NIV and application of Domiciliary NIV

Domiciliary NIV and long term oxygen theraphy was given according to national long-term domiciliary NIV indications [13].

Pressure support ventilation was applied to all domiciliary NIV patients. NIV was administered in the spontaneous/timed (ST) or spontaneos (S) mode with regard to patients synchrony with the ventilator and the ABG values. According to

the tolerance and compatibility of the patient, fullface or oronasal interfaces were used.

Oxygen supplement was added in order to maintain oxygen saturation of 88-92%. Inspiratory positive airway pressure and expiratory positive airway pressure were adjusted according to patients' comfort and arterial blood gase values.

Patients and/or their relatives were trained for domiciliary NIV use before discharge from ICU by senior ICU nurse. One, three and six-month follow-ups were performed after discharge from the ICU.

Domiciliary NIV Compliance

Poor domiciliary NIV compliance was defined as, intermittent use <4 hours/day [14]. NIV use hours was calculated as, total usage hours obtained from NIV device was divided into hours from the NIV initiation day at home to control day in ICU out-patient clinic.

Polysomnography

Polysomnography recordings for all patients were performed full-night and during the spontaneous sleep, using the Neurosoft (Neuron spectrum5, Ivanovia, Russia) brand polysomnography device, in the sleep laboratory and under the supervision of technician. Electroencephalography, electrooculography, chin and tibial electromyography, and electrocardiography were recorded. Airflow was measured using nasal-oral "thermistor" respectively. Chest and abdominal belts were used for ventilator effort during breathing. The scoring was based on the AASM 2012 criteria. In spite of continued breathing effort, pauses in airflow for more than 10 seconds were considered as obstructive apnea, and hypopnea was defined as more than 50% reduction in airflow resulting in 3% oxyhemoglobin desaturation. Apnea hypopnea index (AHI) was determined by calculating mean apnea and hypopnea per hour during sleep time [15]. If the AHI score was 5 or higher, the patient was considered OSA.

Data recorded

Patient characteristics, diagnosis, comorbid diseases, APACHE II (Acute Physiology and Chronic Health Evaluation and Charlson scores, Epworth sleepiness scores, polysomnographic parameters (sleep cycles, total sleep duration, supine AHI, nonsupine AHI, rapid eye movement (REM) AHI, non REM AHI, mean and minumum oxygen saturation, duration to Sleep onset, and number of awakenings), NIV usage hours at home, spirometry values in outpatient clinic, and arterial blood gas (ABG) values (in ICU and out patient clinic), length of ICU stay, were recorded.

Statistical analyses

Descriptive analysis was used to investigate patient demographics and clinical data. The SPSS 20.0 program was used for analysis. Groups were compared using the Mann–Whitney U-tests for non-parametric, continuous variables, or student's t-tests for parametric continuous variables. The median with interquartile range was employed for non-parametric, continuous variables, and the mean ± standard deviation was used for parametric continuous variables. Count and percentage were used when applicable.

Results

Between January 2017-2019, 1850 patients who underwent polysomnography in sleep laboratory were retrospectively evaluated. Among these patients, thirty-four patients who had previously been hospitalized in the respiratory intensive care unit for respiratory failure and were followed-up by domiciliary NIV treatment after discharge were included in the study.

The mean age of the patients' was 67±10 years and 22 (64.7%) were female. 82.4 of the patients were COPD. Demographic features of the patients were summarized in Table 1.

Total sleep time was 347.2 ±61.5 minutes and sleep efficiency was 68±13%. Sleep and REM latency was determined as 19 (13-40), 183 (108-321) minutes respectively. N1, N2, N3 and REM sleep percentage of total sleep time was 5.5 (4.6-8), 62.6 (59-69), 19.7 (13-27), 7.9 (5-13.5) respectively. 70.6% of OSAS patients were accompanied with nocturnal desaturation. The central apneas that determined among the domiciliary NIV patients were 0 (0-2).

Table 1. Characteristics of patients with domiciliary NIV who underwent PSG.

Variables	n	Values
Gender, male,(n,%)	22	64.7
Age, mean (±SD) (year)	34	67±10
Body mass index, mean (±SD) (kg/m²)	32	30±7.4
Cigarette median (IQR) (pack/year)	25	40 (30-45)
Non-smoker, (n,%)	10	29.5
Smoker, (n,%)	1	2.9
Ex-smoker, (n, %)	23	67.6
Diagnoses for ICU demand		
COPD, (n, %)	28	82.4
OHS, (n, %)	1	2.9
OSAS, (n,%)	1	2.9
Bronchiectasis, (n,%)	4	11.8
ILD, (n,%)	1	2.9
Comorbidities		
CHF, (n,%)	14	41.2
CAD, (n,%)	6	17.6
Diabetes Mellitus, (n, %)	14	41.2
Atrial fibrillation, (n, %)	5	14.7
Tuberculosis sequelae, (n,%)	2	5.9

NIV, Non-invasive mechanical ventilation; PSG, polysomnography; COPD, chronic obstructive pulmonary disease; OHS, obesity hypoventilation syndrome; OSAS, obstructive sleep apnea syndrome; ILD, interstitial lung disease; CHD, congestive heart failure; CAD, coronary artery disease; IQR, interquartile range; SD, standard deviation.

Polysomnographic parameters of the domiciliary NIV patients were summarized in Table 2. NIV usage hours in ICU and out-patient clinic were 7 (6-8) and 3.3 (2.1-4.4) hours respectively. ICU and out patient clinic parameters of domiciliary NIV patients were summarized in Table 3.

Discussion

In the present study, abnormal sleep architecture, prolonged sleep and REM latency, decreased sleep efficiency and frequent awakenings were determined among the CRF patients with domiciliary NIV. All patients were accompanied with obstructive sleep apnea syndrome (OSAS) and 70% of them had nocturnal oxygen desaturation

In normal sleep, nonREM stage 1 is nearly 2-5% of total sleep time, nonREM stage 2 is 45-55%, nonREM Stage 3 is 20% and REM is 20-25% [16]. Sleep stages, sleep latency and duration may vary due to age, sex, medications, comorbidities [17]. Sleep quality has been decreased and sleep disturbances occurs frequently in COPD patients, where as most of these symptoms were ignored by clinicians and patients as well [18]. McSharry et al. showed that patients with severe COPD had impaired sleep quality, altered sleep architecture with diminished REM sleep, decreased non-REM sleep stage 3 (N3) and sleep efficiency [19]. In the present study, decreased N3 and REM sleep was observed in CRF patients (82.4% was COPD) with domiciliary NIV. Since the COPD rate is very high among the study group, our findings are similar with the other studies [19, 20]. Nocturnal oxygen desaturation, arousals, wheezing and cough due to COPD might be the reason of sleep division and decreased sleep latency.

Table 2. Polysomnographic parameters of patients with domiciliary NIV.

Variables	n	Values
ESS, median(IQR)	34	3 (1-5)
Total sleep time, mean(±SD), (minute)	34	347.2±61.5
Sleep efficency, mean(±SD), (%)	34	68±13
Sleep latency, median(IQR), minute	34	19 (13-40)
REM latency, median(IQR), minute	34	183 (108-321)
REM number, median(IQR)	34	2 (1-4)
WASO, median(IQR), minute	34	103.8 (69.5-132.5)
Number of awakenings, median(IQR)	34	18 (12-23)
Sleep stage percentage of TST		
N1, median(IQR)	34	5.5 (4.6-8)
N2, median (IQR)	34	62.6 (59-69)
N3, median(IQR)	34	19.7 (13-27)
REM, median(IQR)	34	7.9 (5-13.5)
Minimum oxygen saturation, mean(±SD),%	34	69±14
Minimum oxygen saturation REM, mean(±SD), %	34	76 (66-82)
Mean oxygen saturation, median(IQR),%	34	89 (87-91)
Mean oxygen saturation REM, median(IQR), %	34	87 (83-89)
Mean oxygen saturation non-REM, median(IQR), %	34	90 (87-91)
Oxygen saturation<90, median (IQR),%	34	85.4 (34.9-100)
AHI, median(IQR)	34	24.3 (13-42)
Supin AHI, median(IQR),	34	37.7 (15.8-67.3)
Non-supin AHI, median(IQR),	34	18.6 (9-36.6)
REM AHI,	34	31.4 (20-41.2)
Non-REM AHI, median(IQR),	34	23.5 (12.4-41)
Type of OSAS		
OSAS, (n,%)	7	20.6
OSAS+ nocturnal hypoxia, (n,%)	24	70.6
Positional OSAS, (n,%)	2	5.9
REM OSAS, (n, %)	1	2.9
Central apne, median(IQR)	34	0(0-2)

NIV, Non-invasive mechanical ventilation; ESS, Epworth sleepiness scale; WASO, wake after sleep on set; TST, total sleep time; REM, rapid eye movement; AHI, apnea hypopnea index; OSAS, obstructive sleep apnea syndrome; IQR, interquartile range; SD, standard deviation.

Table 3. ICU out patient clinic and ICU features of domiciliary NIV patients.

Variables	n	Values
Non invasive mechanical ventilation days, median (IQR)	26	6 (5-8)
Invasive mechanical ventilation days, median (IQR)	14	1 (0-2)
NIV use in ICU, median (IQR), hour	26	7 (6-8)
NIV use in out-patient clinic, median (IQR), hour	28	3.3 (2.1-4.4)
Arterial blood gase values		
ph during ICU discharge, median (IQR)	26	7.43 (7.40-48)
PCO2 during ICU discharge, mean(±SD), mmHg	26	52±8
PO2 during ICU discharge, median (IQR), mmHg	26	91 (83-98)
HCO3 during ICU discharge, mean(±SD), mlEq/lt	26	34±4
Oxygen saturation during ICU discharge, mean (±SD), %	26	97±3
ph during ICU outpatient clinic, median (IQR)	28	7.42 (7.39-7.43)
PCO2 during ICU outpatient clinic, mean(±SD), mmHg	28	52±8
PO2 during ICU outpatient clinic, mean(±SD),mmHg	28	74±14
HCO3 during ICU outpatient clinic, mean(±SD), mlEq/lt	28	28±3
Oxygen saturation during ICU outpatient clinic, mean(±SD), %	25	94±3
APACHE II score, median (IQR)	26	16 (12-22)
Charlson score, median (IQR)	26	4 (3-5)

ICU, Intensive care unit, NIV, noninvasive mechanical ventilation; PCO2, partial carbondioxide pressure, PO2, partial oxygen pressure, HCO3, bicarbonate; IQR, interquartile range; SD, standard deviation. APACHE II, acute physiology and chronic health evaluation.

Co-existence of OSAS and COPD were defined as 'Overlap Syndrome'. Morning headache is an important symptom for the accompanying OSAS especially in obese, snoring, COPD patients receiving oxygen therapy [21]. In the present study, nearly half of the study population had snoring and day time sleepiness however 17% had witnessed apnea. According to body mass index calculation, our study group was obese (median, 30±7.4 kg/m2). In a recent study conducted in patients with mild COPD, OSAS was found to be 3% [22]. But there is no adequate data about the prevelance of OSAS in CRF patients with domiciliary NIV. In the present study, all patients in the study group had OSAS and nocturnal desaturation, besides majority were COPD.

Several factors related to COPD may protect against the development of OSA, such as cachexia due to systemic inflammation in COPD, diminished REM sleep and using theophylline for medication [23, 24]. However, fluid shift in supine position due to cor pulmonale, upper airway oedema caused by cigarette smoking, fat deposition due to corticosteroid theraphy triggers the development of OSA in COPD patients [25, 26]. In the present study all patients were accompanied with obstructive sleep apnea syndrome (OSAS) and majority of the CRF cases were COPD.

Reduction in accessory muscle activity and loss of tonic activity in intercostal muscles during REM sleep causes hypoventilation especially in severe COPD patients [2]. In our study, severe oxygen desaturation was observed in REM sleep. Mc Evoy et al. showed small but significant increase in REM sleep and decrease in transcutaneous PCO2 with NIV treatment [26]. In the present study, the effects of NIV treatment on sleep stages were not investigated but PCO2 values were compared as outpatient clinic and discharge values. In out patient clinic CRF patients had lower PCO2 values than the discharge. Additionally, according to data obtained from ICU out-patient clinic, NIV compliance was low in CRF patient with domiciliary NIV. It was shown that low NIV compliance was failed to normalize sleep architecture and gas exchange during sleep [26]. In the present study, NIV compliance on sleep architecture was not evaluated.

There are some limitations of our study. The sample size was modest compared to other studies analyzing the polysomnographic features of the domiciliary NIV patients. Our study population consists of severe CRF patients mostly COPD, thus our findings can not be generalized to the whole CRF patients. The strength of this study lies in the fact that all the CRF were followed-up after ICU discharge by the same ICU team, which consisted of intensivists and pulmonologists, and the polysomnography recordings was performed by the same clinicians consisted of pulmonology. Therefore larger-scale studies are warranted in CRF patients.

In conclusion, present study demonstrates abnormal sleep architecture and sleep related abnormalities in patients with CRF using domicilary NIV. In normocapnic CRF patients with domiciliary who are planned to cessate NIV due to low compliance, polysomnography should be performed before the cessation of NIV. Polysomnography together with clinical findings, sleepiness scores, arterial blood gase values would help the clinicans in daily practice.

Conflict of interest: No conflict of intereset is declared by the authors.

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The Univercity of Health Sciences Süreyyapaşa Chest Diseaes and Chest Surgery Training Hospital local ethics committee approved the study (number/date, 077/21.08.2019) and it was in accordance with the Declaration of Helsinki.