

Sleep after critical illness: Study of survivors of acute respiratory distress syndrome and systematic review of literature

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Abstract

Background and Aims: This study aims to evaluate the sleep quality, architecture, sleep-related quality of life, and sleep-disordered breathing (SDB) in acute respiratory distress syndrome (ARDS) survivors early after discharge. **Materials and Methods:** In this prospective, observational study, consecutive patients with ARDS discharged from the Intensive Care Unit (ICU) underwent evaluation with Epworth sleepiness scale (ESS), Pittsburgh Sleep Quality Index (PSQI), Functional Outcomes of Sleep Questionnaire (FOSQ), and overnight polysomnography. Patients having one or more of the following characteristics were classified as having abnormal sleep: ESS >10, PSQI >5, FOSQ <17.9, apnea-hypopnea index (AHI) ≥5, or AHI during rapid eye movement (REM) sleep ≥5. **Results:** Twenty patients (median interquartile range [IQR] age of 24 [22–28] years, 11 [55%] females) were included in the study. Acute febrile illness of unknown etiology with multi-organ dysfunction syndrome was the most common underlying etiology for ARDS. The median (IQR) PaO₂/FiO₂ ratio and APACHE II scores on admission were 176 (151–191.5) and 14 (14–16), respectively. The median (IQR) duration of stay in the ICU was 10 days (7.3–19.5). The overall sleep efficiency (median [IQR], 54% [32.3–65.4%]) was poor. None of the patients had ESS >10, seven (35%) had global PSQI >5 and one had FOSQ <17.9. Ten (50%) patients had at least one characteristic that suggested abnormal sleep (4 insomnia, 2 central sleep apnea, 1 obstructive sleep apnea, 1 REM-SDB, and 2 with a high PSQI, but no specific sleep abnormality). **Conclusions:** Sleep disturbances are common in ARDS survivors early after discharge from the ICU.

Keywords: Acute respiratory distress syndrome, critically ill, Intensive Care Unit, mechanical ventilation, obstructive sleep apnea, sleep apnea

Access this article online

Website: www.ijccm.org

DOI: 10.4103/0972-5229.183908

Quick Response Code:



Introduction

Sleep disturbances are encountered in critically ill patients admitted to the Intensive Care Unit (ICU).^[1] The etiology is multifactorial including the acute illness itself, noisy environment of the ICU, exposure to light during the night, interruptions due to patient care-related

activities, altered circadian rhythm, medications, and others.^[1-6] Patients with the acute respiratory distress syndrome (ARDS) have severe acute illness, require mechanical ventilation in a majority of the instances.

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How to cite this article: Dhooria S, Sehgal IS, Agrawal AK, Agarwal R, Aggarwal AN, Behera D. Sleep after critical illness: Study of survivors of acute respiratory distress syndrome and systematic review of literature. *Indian J Crit Care Med* 2016;20:323-31.

They are predisposed to the risk of patient-ventilator dyssynchrony and frequently require sedatives and other psychotropic medications. All these factors make them a unique population, especially prone to sleep disturbances. Severe disruptions have been reported in the sleep architecture in this subgroup of patients.^[7] Sleep disturbance that arises during the stay in the ICU may continue long after discharge.^[8] Survivors of ARDS suffer from many adverse physical and psychological sequelae and decreased quality of life.^[9] Chronic sleep disorders such as insomnia and sleep apnea present several months after discharge in these patients and contribute to the impaired quality of life.^[8,10]

Sleep architecture has been previously studied in ARDS patients during the stay in the ICU.^[7] Chronic sleep disorders have been described in the survivors of ARDS several months after discharge.^[8,10] Sleep disturbances have also been studied in the general population of critically ill patients both in the early and late postdischarge periods.^[11] We wanted to determine the prevalence of sleep disturbances diagnosed on the basis of a composite criterion in a uniform study population (of subjects with ARDS) early in the postdischarge period. In this study, we describe the changes in sleep quality, sleep-related quality of life, sleep architecture, and the prevalence of sleep-disordered breathing (SDB) in the survivors of ARDS early after discharge. We also perform a systematic review of studies describing sleep disturbances in patients discharged from ICUs after recovery from critical illness (with or without ARDS).

Materials and Methods

This was a prospective observational study conducted between July 2011 and September 2012 in the Department of Pulmonary Medicine of this institute. All patients provided informed consent and the study protocol was approved by the Ethics Review Committee.

Study participants

Patients were included in the study if they satisfied all the following criteria: (i) Age 18–65 years, (ii) ARDS defined by the American-European Consensus Conference criteria,^[12] (iii) ICU stay of at least 48 h duration, (iv) intubated and mechanically ventilated for ≥ 24 h, (v) successfully extubated and discharged from the respiratory ICU after weaning from mechanical ventilation and survived for ≥ 1 month, and (vi) provided an informed consent to participate in the study. Patients with any of the following characteristics were excluded: (i) Known psychiatric, neurological, cognitive, or sleep disorder prior to the present illness, (ii) receiving any sedative or psychotropic medication after discharge from

the ICU, (iii) discharge after getting tracheostomized, and (iv) failure to provide an informed consent. Patients were enrolled and all the study procedures were conducted at 1 month of discharge from the ICU.

Study setting and procedures

The respiratory ICU comprises eight beds, has a nurse: Patient ratio of 1:2, and is overseen by a team of six pulmonary and critical care consultants. The nursing care is provided by a qualified nurse with assistance from the hospital attendants under the direct supervision of the doctors on duty (two pulmonary fellows at all times throughout the day and night). All patients are subjected to appropriate laboratory investigations and therapeutic management during their stay according to the ICU protocols.^[13,14]

Demographic details (age, gender, and body mass index [BMI]) were recorded for all the included patients. The etiology of ARDS and the PaO₂/FiO₂ ratio at presentation were noted. All of them underwent endotracheal intubation and mechanical ventilation. Assist-control (volume controlled) mode of ventilation was used for all patients during the initial phase according to the ARDSNet protocol whereas pressure support ventilation was employed during the weaning period.^[15] The duration of ICU stay and mechanical ventilation, the dose and duration of sedatives and neuromuscular blockers, and the respective cumulative doses were recorded. The severity of the illness was assessed with the APACHE II score calculated within 24 h of ICU stay.

Measures of sleepiness, sleep quality, and sleep-related quality of life

All patients completed the Epworth Sleepiness Scale (ESS), a self-administered questionnaire which rates the likelihood of falling asleep (from 0 to 3) under eight different daily life situations.^[16] The maximum score is 24 and a score above 10 indicates significant daytime sleepiness. The patients also responded to the Pittsburgh Sleep Quality Index (PSQI), a scale used for the subjective assessment of sleep quality.^[17] The questionnaire consists of 19 items with responses arranged on an integer scale from 0 to 3, which assesses seven components of sleep quality: Subjective sleep quality, latency, duration, and efficiency; sleep disturbances, sleeping medication use, and daytime dysfunction. The total sleep quality score, obtained by adding the component scores, ranges between 0 and 21, with higher scores representing lower sleep quality. A score above 5 indicates poor sleep quality. The scale can be adapted to enable the subject to respond verbally to items on the scale by having an interviewer read the statement to the subjects. Finally,

the study participants also completed the Functional Outcomes of Sleep Questionnaire (FOSQ), which comprises 30 items, each item coded on a five-point scale (from 0 to 4).^[18] It assesses the impact of excessive sleepiness in five domains: Activity level, vigilance, intimacy and sexual relationships, general productivity, and social outcome. The total score ranges from 5 to 20 and a score of more than 17.9 is used as the threshold for defining a normal sleep-related quality of life.^[19] All the questionnaires were in English. All study participants completed the questionnaires under supervision (and if needed with some help from the interviewer), following a detailed explanation.

Polysomnography

An overnight polysomnography (PSG) was performed on all study subjects within a month of discharge from the ICU. Monitoring of the electroencephalogram using two frontal, two central, and two occipital channels (placed according to the international 10–20 system), electro-oculogram, submental and anterior tibialis electromyogram, electrocardiogram (lead I), chest and abdominal movements, airflow (using oronasal thermal sensor and nasal air pressure transducer), and pulse oximetry was performed. Sleep scoring was done according to 2007 American Academy of Sleep Medicine criteria.^[20] Apnea-hypopnea index (AHI) was calculated for each patient. The total sleep duration, duration of each sleep stage, and sleep efficiency were calculated. AHI during rapid eye movement (REM) sleep (AHI-REM) was also separately calculated. SDB was defined by AHI ≥ 5 , while SDB-REM was defined by an AHI-REM ≥ 5 .

Patients having one or more of the following characteristics were classified as having abnormal sleep: ESS >10, PSQI >5, FOSQ <17.9, AHI ≥ 5 , or AHI-REM ≥ 5 .

Statistical analysis

Statistical analysis was performed using the commercial statistical package SPSS (Version 22 for MS-Windows, IBM Corp., Armonk, New York, USA). Continuous data are expressed as mean (standard deviation [SD]) or median (interquartile range [IQR]), based on the Shapiro–Wilk test of normality, whereas categorical data are expressed as number with percentage. Differences in continuous variables between two groups were compared using the Mann–Whitney U-test. $P < 0.05$ was considered statistically significant.

Results

A total of 360 patients were admitted to the respiratory ICU during the study period; 74 (20.6%) had a diagnosis

of ARDS, of which 50 (67.6%) patients survived their ICU stay. Of these, eight fell outside the age limits of the study, five had known psychiatric and/or sleep disorders, three were managed on noninvasive ventilation, five patients were discharged on a tracheostomy, four patients died within 1 month of discharge, and five patients refused to provide informed consent. Finally, twenty patients (median [IQR] age 24 [22–28] years, 11 [55%] females) were enrolled in this study [Table 1]. Acute febrile illness of unknown etiology with multi-organ dysfunction syndrome was the most common underlying etiology for ARDS. The median (IQR) PaO₂/FiO₂ ratio and APACHE II scores were 176 (151–191.5) and 14 (14–16), respectively. The median (IQR) duration of stay in the ICU was 10 (7.3–19.5) days. Midazolam (14 [70%] patients) and vecuronium (12 [60%] patients) were the most commonly employed sedative and neuromuscular blocking agents, respectively.

Table 1: Baseline characteristics of the study population

Characteristics	Value
Age, years	24 (22-28)
Females	11 (55)
BMI, kg/m ²	20 (18.0-23.8)
Duration of stay in ICU, days	10 (7.3-19.5)
PaO ₂ /FiO ₂ ratio	176 (151-191.5)
Comorbidities	
Hypertension	2 (10)
Diabetes mellitus	1 (5)
Etiology of ARDS	
Acute febrile illness of unknown etiology with MODS	5 (25)
Aspiration pneumonia	1 (5)
Community-acquired pneumonia	3 (15)
Complicated malaria	1 (5)
Enteric fever	1 (5)
Postoperative MODS	2 (10)
Snake bite	1 (5)
Scrub typhus	4 (20)
Tuberculosis	1 (5)
Varicella pneumonia	1 (5)
Septic shock	10 (50)
Administration of sedatives	
Midazolam	14 (70)
Morphine	4 (20)
Fentanyl	5 (25)
Haloperidol	3 (15)
Duration of sedative use, days	5 (3-11)
Cumulative doses of sedatives, mg	
Midazolam	81 (38.8-178.8)
Morphine	6 (3-42)
Fentanyl	150 (100-250)
Haloperidol	9 (5-20)
Administration of neuromuscular blockers	
Vecuronium	12 (60)
Atracurium	1 (5)
Duration of neuromuscular blocker use, days	3 (1-9)
Cumulative doses of neuromuscular blockers, mg	
Vecuronium	32.5 (21.8-59.3)
Atracurium	50

All values are median (IQR) or number (%). ARDS: Acute respiratory distress syndrome; ICU: Intensive Care Unit; MODS: Multi-organ dysfunction syndrome; IQR: Interquartile range; BMI: Body mass index

None of the patients had an ESS score (median [IQR] score of 6 [3.3–7]) of more than 10 [Table 2]. Seven (35%) patients had a global PSQI above the threshold score of 5, representing poor overall sleep quality. The mean (SD) global FOSQ was 18.37 (0.62), with only one patient having a FOSQ score below the conventionally used cutoff of 17.9. Ten (50%) patients did not respond to the sexual and intimacy component of the FOSQ scale. The overall sleep efficiency (median [IQR], 54% [32.3–65.4%]) was poor [Table 3]. Most of the sleep duration comprised stage 1 and 2, while slow wave and REM sleep together accounted for 21.4% (median) of the total sleep duration. The median (IQR) AHI was 1.9 (0.7–2.7). Three (15%) and six (30%) patients had AHI and AHI-REM ≥ 5 , respectively [Table 3]. Overall, ten (50%) of the twenty patients had at least one of the following characteristics signifying abnormal sleep: ESS >10, PSQI >5, FOSQ <17.9, AHI ≥ 5 , or AHI-REM ≥ 5 . Of these, four had insomnia (all had complaints of difficulty initiating sleep), two had central sleep apnea, and one had obstructive sleep apnea (OSA). In one patient, REM SDB was the predominant abnormality detected. In two other patients, the PSQI was high; however, no specific sleep abnormality could be identified. On comparing the characteristics of subjects with ($n = 3$) and without ($n = 17$) SDB (i.e. AHI ≥ 5), those with SDB had a longer duration of receiving sedation in the ICU ($P = 0.048$) with higher cumulative doses of midazolam ($P = 0.044$) administered.

Discussion

This study demonstrates that at least one parameter representing abnormal sleep is present in half of the mechanically ventilated ARDS patients early after discharge from the ICU. In this study, we adopted a multi-pronged approach in an attempt to capture the different aspects of sleep disturbances including daytime sleepiness (using ESS), sleep quality (using PSQI), sleep-related quality of life (using FOSQ), and specific sleep abnormalities such as SDB (using PSG). To our knowledge, this is the first study in which an unselected group of ARDS patients has been evaluated early in the post-ICU discharge period, irrespective of the presence or absence of any sleep-related complaints.

We searched the PubMed and EMBASE databases for relevant studies describing the occurrence of sleep disturbances after recovery from critical illness (with or without ARDS) using the following search terms: (“sleep disordered breathing” OR “sleep apnoea” OR “sleep apnoea” OR “sleep quality” OR “sleep-related quality of life” OR “sleep disorders” OR “sleep disturbances”) AND (“acute respiratory distress syndrome” OR “ards”

Table 2: Daytime sleepiness, sleep quality, and sleep-related quality of life as assessed by Epworth Sleepiness Scale, Pittsburgh Sleep Quality Index, and Functional Outcomes of Sleep Questionnaire in study subjects

Item	Score
ESS	6 (3.3-7)
ESS > 10	0
PSQI	
Component 1 (subjective sleep quality)	1 (0.25-1)
Component 2 (sleep latency)	1 (1-2)
Component 3 (sleep duration)	1 (0-1)
Component 4 (habitual sleep efficiency)	0 (0)
Component 5 (sleep disturbances)	1 (1-1)
Component 6 (use of sleep medication)	0 (0-0)
Component 7 (daytime dysfunction)	1 (1-2)
Global PSQI	5 (4-7)
Patients with PSQI >5, n (%)	7 (35)
FOSQ, mean \pm SD	
General productivity	3.75 (3.62-3.75)
Vigilance	3.80 (3.63-3.80)
Social outcome	3.75 (3.50-4.00)
Activity level	3.56 (3.44-3.67)
Intimacy	3.75 (3.69-3.75)
Global FOSQ, mean \pm SD	18.50 (18.09-18.73)
Global FOSQ < 17.9, n (%)	1 (5)

All values are median (IQR) unless stated otherwise. SD: Standard deviation; IQR: Interquartile range; ESS: Epworth Sleepiness Scale; PSQI: Pittsburgh Sleep Quality Index; FOSQ: Functional Outcomes of Sleep Questionnaire

Table 3: Polysomnographic characteristics and type of sleep abnormality in the study participants

Characteristics	Value
Total sleep time, min	278.5 (201.8-383.1)
Sleep latency, min	21.5 (8.4-61.0)
Sleep efficiency, percentage of total time in bed	54 (32.3-65.4)
Sleep stages, percentage of total sleep time	
Stage 1	24.4 (16.6-48.5)
Stage 2	45.8 (23.3-60.9)
Slow wave sleep	15.9 (8.4-24.1)
REM	5.5 (2.3-15.1)
AHI	1.9 (0.7-2.7)
AHI ≥ 5	3 (15)
AHI-REM ≥ 5	6 (30)
Oxygen saturation while awake	98 (97-99)
Minimum oxygen saturation during sleep	94 (85-95)
Desaturation index	2.3 (1-6.8)
Sleep abnormality	
Insomnia	4 (20)
Central sleep apnea	2 (10)
Obstructive sleep apnea	1 (5)
REM sleep-disordered breathing	1 (5)
High PSQI without specific sleep abnormality	2 (10)

All values are median (IQR) or number (%). AHI: Apnea-hypopnea index; PSQI: Pittsburgh Sleep Quality Index; REM: Rapid eye movement; IQR: Interquartile range; PSQI: Pittsburgh Sleep Quality Index; ESS: Epworth Sleepiness Scale

OR “adult respiratory distress syndrome” OR “acute lung injury” OR “critical illness” OR “critically ill” OR “intensive care” OR “ICU” OR “mechanical ventilation” OR “mechanically ventilated”). From the EMBASE database, citations under only the two categories, “articles” and “articles in press” were included. We reviewed the list of references of original studies, editorials, and

reviews; and also sifted through our personal files. We excluded case reports, abstracts, comments, editorials, and reviews; studies describing the quality of sleep or sleep disturbances during ICU stay; studies describing the outcomes of patients with known sleep disorders (e.g., OSA); studies performed only in the pediatric population; and studies performed in noncritically ill hospitalized patients or in postoperative subjects.

The initial database search yielded 991 studies, of which 17 studies (2314 subjects) met the inclusion criteria [Figure 1 and Table 4].^[8,11,21-35] The instruments used to assess sleep disorders/disturbances varied widely from unstructured questionnaires to specific

instruments, while PSG was performed in only four studies.^[8,23,29,31] Most studies described the proportion of patients having poor sleep quality, sleep disturbances, or sleep-related symptoms, while the studies in which PSG was performed also reported sleep efficiency, sleep latency, sleep architecture, and/or AHI [Table 5]. Fourteen studies reported the percentage of patients with abnormal sleep (subjective or objective).^[8,11,21,23,24,26-28,30-35] Six of these were performed early (<1 month) and five late (>1 month) after discharge while three studies reported on both early and late outcomes [Table 6]. The median (range) percentage of patients having abnormal sleep was higher in the early period (66.7% [40.4–80%]) than in the late period (38.5% [6.4–57%]).

Table 4: Characteristics of the included studies

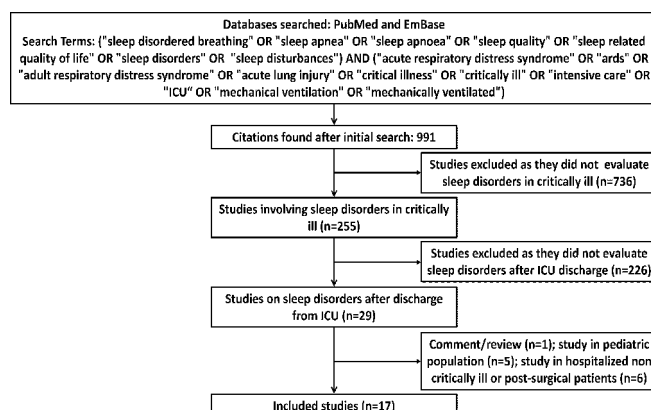
Author (year)	Country	Design	Type of ICU	Number of patients	Patient population	Instruments used to assess sleep
Hall-Smith <i>et al.</i> (1997) ^[21]	United Kingdom	Prospective	Not mentioned	26	ICU stay >5 days	Unstructured, client-led interview
Niskanen (1999) ^[22]	Finland	Prospective	Medical-surgical	368	At least one ICU admission lasting ≥ 96 h	Finnish version of the NHP
Chishti <i>et al.</i> (2000) ^[23]	United Kingdom	Prospective	Medical-surgical	15	Received >48 h of mechanical ventilation in ICU	Overnight, multi-channel pneumographic studies
Dimopoulou <i>et al.</i> (2001) ^[24]	Greece	Prospective	Cardiac surgical	16	Cardiac surgery patients with an unexpected cardiac arrest in the immediate postoperative period	A specific questionnaire based on the NHP
Combes <i>et al.</i> (2003) ^[25]	France	Prospective	Medical-surgical	87	Consecutive patients mechanically ventilated for ≥ 14 days in ICU	French version of the NHP
Strahan <i>et al.</i> (2003) ^[26]	Northern Ireland	Prospective	Medical-surgical	170	Patients with an ICU stay >24 h and discharged to the general ward	Original questionnaire developed by investigators
Granja <i>et al.</i> (2005) ^[27]	Portugal	Prospective	Medical-surgical	373	All adult ICU patients 6 months after discharge	Original questionnaire
Strahan <i>et al.</i> (2005) ^[28]	United Kingdom	Prospective	Surgical	10	Patients shifted to the wards from ICU	Phenomenological approach
BaHammam (2006) ^[29]	Saudi Arabia	Prospective	Cardiac	20	Consecutive patients with a first-ever acute ST segment elevation myocardial infarction admitted to the coronary care unit	PSG
Orwelius <i>et al.</i> (2008) ^[30]	Sweden	Prospective	Medical-surgical	497	Consecutive admitted adults with ICU stay >24 h, and alive at 6 months of hospital discharge	Swedish version of the Basic Nordic Sleep Questionnaire
Lee <i>et al.</i> (2009) ^[9]	Canada	Prospective	Medical-surgical	109	Survivors of acute respiratory distress syndrome after discharge from the ICU	Sleep history questionnaire, two Insomnia Severity Index questionnaires, ESS, overnight PSG
Fanfulla <i>et al.</i> (2011) ^[31]	Italy	Prospective	Medical-surgical	22	Patients shifted from the ICU to a step down unit	24 h PSG
McKinley <i>et al.</i> (2012) ^[32]	Australia	Prospective	Medical-surgical	186	Mechanically ventilated for >24 h with ICU stay ≥ 48 h, and discharged home	15D HRQOL instrument with a five-point scale
McKinley <i>et al.</i> (2013) ^[11]	Australia	Prospective	Medical-surgical	199	ICU stay of ≥ 2 nights with no known history or evidence of sleep disorder	Richards Campbell Sleep Questionnaire, Pittsburgh Sleep Quality Index
Vesz <i>et al.</i> (2013) ^[33]	Brazil	Prospective	Medical-surgical	79	Admitted to and discharged from the ICU with stay ≥ 72 h	ESS
Choi <i>et al.</i> (2014) ^[34]	United States	Prospective	Medical	33	Admitted to a medical ICU, on mechanical ventilation for ≥ 4 consecutive days	Modified Given Symptom Assessment Tool
Soh <i>et al.</i> (2014) ^[35]	Malaysia	Prospective	Not mentioned	104	Ventilated, with stay >24 h, with no gross neurological deficit and no history of psychotic episodes	Questionnaire adapted from Granja <i>et al.</i> ^[27]

HRQOL: Health-related quality of life; ICU: Intensive Care Unit; ESS: Epworth Sleepiness Scale; NHP: Nottingham health profile; PSG: Polysomnography

Table 5: Time point of assessment and sleep disturbances reported in the included studies

Author (year)	Time point of assessment	Sleep disturbances
Hall-Smith <i>et al.</i> (1997) ^[21] Niskanen <i>et al.</i> (1999) ^[22]	3 months after hospital discharge 6 months after discharge	3 (11.5%) patients had poor sleep Sleeping disturbances more frequent among patients undergoing open-heart surgery or having respiratory failure than those with neurosurgical disease ($P < 0.01$ and $P < 0.001$, respectively). Less common among younger patients (18-34 years) than those older (55-64 years and 65-74 years; $P < 0.01$ for both)
Chishti <i>et al.</i> (2000) ^[23]	Within 72 h of discharge from the ICU	11 (73.3%) patients had abnormal apnea/hypopnea index (range 5-34 events/h). Time spent in some form of abnormal breathing pattern varied between 6 and 41% of the study period
Dimopoulou <i>et al.</i> (2001) ^[24] Combes <i>et al.</i> (2003) ^[25]	4 years postdischarge Cross-sectional study (various time points)	6 (38%) patients had mild sleep disturbances, such as early awaking Mean NHP scores for sleep significantly higher than general population and higher in ARDS patients as compared to the rest
Strahan <i>et al.</i> (2003) ^[26]	87% of questionnaires completed in the immediate post-transfer period between days 1 and 15 (mean 8.6) after ICU discharge	114 (67%) patients experienced "trouble getting to sleep"
Granja <i>et al.</i> (2005) ^[27] Strahan and Brown (2005) ^[28]	6 months after discharge 3-5 days after transfer from ICU	Sleep disturbances in 153 (41%) patients 8 (80%) patients described symptoms including tiredness, sleep difficulties, and sleep disorders
BaHammam (2006) ^[29]	3 days after acute MI and 6 months later	Mean sleep efficiency: 62% at 3 days and around 81.4% at 6 months Mean sleep latency: 24.9 min at 3 days, 19.6 min at 6 months
Orwelius <i>et al.</i> (2008) ^[30]	6 and 12 months after discharge from hospital	38% had difficulties falling asleep, 20% had poor sleep quality, and 39% reported sleep deficit
Lee <i>et al.</i> (2009) ^[8]	Average 64 weeks (range, 22-168) following discharge from ICU	Seven (6.4%) survivors reported persistent sleep-related symptoms Difficulty initiating and maintaining sleep: 5, parasomnia: 1, frequent nightmares: 1 ESS median (range): 8.5 (2-16) Sleep efficiency (median [range]): 80.2% (50.8-95.0%) Sleep latency (median [range]): 14.9 (2.1-174.1) min Slow wave sleep (median [range]): 23.5% (7.0-32.3%) REM sleep (median [range]): 19.7% (5.6-24.3%)
Fanfulla <i>et al.</i> (2011) ^[31]	10.2±8.7 days after admission	10 (45.5%) patients showed reduced sleep efficiency (< 70%), 6 patients had a reduced REM percentage or no REM sleep, and 3 had reduced or absent slow wave sleep In spontaneously breathing patients: Slow wave sleep (mean): 31.9%, REM sleep (mean): 14.2%
McKinley <i>et al.</i> (2012) ^[32]	Weeks 1, 8, and 26 after hospital discharge (sleep data available for week 1 and 26)	Moderate (disturbed sleep or feeling I have not slept enough) to severe (sleep is almost impossible even with full use of sleeping pills or staying awake most of the night) sleep problems in 50% at week 1 and 31% at week 26
McKinley <i>et al.</i> (2013) ^[11]	1-2 days after transfer to ward and 2 and 6 months after discharge	Poor sleep quality in 68% after 1-2 nights on the ward and in 62% and 57% at 2 and 6 months, respectively, after discharge
Vesz <i>et al.</i> (2013) ^[33]	During 1 st week following discharge from ICU	43.3% with ESS score ≥ 10
Choi (2014) ^[34]	≤2 weeks and at 2 and 4 months after ICU discharge	Disturbed sleep at ≥2 weeks: 66.7%, 2 months: 64.3%, 4 months: 46.2%
Soh <i>et al.</i> (2014) ^[35]	Within 3 days of discharge from ICU	Sleep disturbances in 42 (40.4%) patients

ARDS: Acute respiratory distress syndrome; ICU: Intensive Care Unit; MI: Myocardial infarction; NHP: Nottingham health profile; REM: Rapid eye movement; ESS: Epworth Sleepiness Scale

**Figure 1: Citation selection process for the systematic review**

For the present study, we selected a specific subgroup of subjects among the patient population in the ICU, i.e., those with ARDS. This group is relatively uniform since nearly all these patients require invasive mechanical ventilation and many of them have multi-organ dysfunction. A previous study on sleep disturbances in ARDS survivors showed that 6.4% of the subjects reported persistent sleep-related symptoms 6 months or more following discharge from the ICU.^[8] In contrast, in the present study where consecutive ARDS survivors were included much earlier in the postdischarge period (within a month), a remarkably higher prevalence (50%) of abnormal sleep was found. One contributing factor

Table 6: Percentage of patients with abnormal sleep in studies performed in the early (< 1 month) and late (> 1 month) period after discharge

Author (year)	Percentage of patients with abnormal sleep (%)
Early	
Chishti <i>et al.</i> (2000) ^[23]	73.3
Strahan <i>et al.</i> (2003) ^[26]	67
Strahan and Brown (2005) ^[28]	80
Fanfulla <i>et al.</i> (2011) ^[31]	45.5
McKinley <i>et al.</i> (2012) ^[32]	50
McKinley <i>et al.</i> (2013) ^[11]	68
Vesz <i>et al.</i> (2013) ^[33]	43.3
Choi <i>et al.</i> (2014) ^[34]	66.7
Soh <i>et al.</i> (2014) ^[35]	40.4
Median (range)	66.7 (40.4-80)
Late	
Hall-Smith <i>et al.</i> (1997) ^[21]	11.5
Dimopoulou <i>et al.</i> (2001) ^[24]	38
Granja <i>et al.</i> (2005) ^[27]	41
Orwelius <i>et al.</i> (2008) ^[30]	39
Lee <i>et al.</i> (2009) ^[8]	6.4
McKinley <i>et al.</i> (2012) ^[32]	31
McKinley <i>et al.</i> (2013) ^[11]	57
Choi <i>et al.</i> (2014) ^[34]	46.2
Median (range)	38.5 (6.4-57)

for finding a high prevalence of abnormal sleep is that a broad definition of abnormal sleep was considered in the present study. We have used multiple parameters (3 questionnaires and PSG) so as to be able to capture a higher proportion of patients with any type of sleep disturbance/reduced sleep quality/reduced sleep-related quality of life. The prevalence of abnormal sleep found in this study is consistent with the results of the systematic review in which 40–80% of critically ill patients had evidence of sleep disturbances within a month of discharge from the ICU. The most common sleep disorder was insomnia as in other studies.^[8,26,30]

The reason why sleep disruption is so common early in the recovery period is uncertain. While it is well known that many environmental factors such as sound, light, ventilator, and patient care activities disrupt sleep in patients during their stay in the ICU, it is possible that the sleep pattern associated with critical illness and admission to the ICU may continue to persist for some period after discharge.^[1,11] This type of sleep disruption originating during ICU admission possibly extends into the recovery period and gradually resolves in a proportion of the patients as time elapses. As evident from the systematic review, the proportion of patients reported to have sleep disruption was higher in the early period (median 67%), climbing down to 39% in the late period. The findings from the present study and the systematic review suggest that greater attention must be paid to sleep parameters during the early follow-up period of ARDS patients discharged from the ICU.

Sleep disturbances should be specifically looked for and managed accordingly; this might help in improving the sleep-related quality of life.

Seven of our patients had a global PSQI higher than the threshold value of 5 suggesting a poor overall sleep quality. Yet none of our patients had an ESS >10 suggesting that ESS that assessed only subjective excessive daytime sleepiness may be a poor measure of assessing sleep disturbances in this population. The PSQI questionnaire is more comprehensive and assesses the sleep quality based on seven different components, and hence is more robust.^[17] A previous study that employed the PSQI also found that poor sleep quality in a high proportion (70%) of patients at 1–2 day after discharge from the ICU.^[11] Contrarily, the global FOSQ was higher than 17.9 in most of the patients in our study, suggesting a good sleep-related quality of life. One of the possible reasons for this incongruity is that half of our patients did not respond to the sexual and intimacy component of the scale as sex-related issues are considered taboo for a large number of individuals in our community.

SDB was observed in only 3 (15%) of the patients in the current study, in contrast to the findings of Chishti *et al.*, in which 73% of the patients had AHI >5.^[23] The potential reason for the discrepancy is that in studies of ICU survivors, it is not possible to ascertain whether the SDB was preexisting or appeared after the acute illness. Furthermore, the prevalence of SDB is higher with increasing age and BMI.^[36] In the present study, both the median age (24 years) and the median BMI (20.0 kg/m²) of the patients were low. Due to this reason, the subjects in our study had a lower probability of having preexisting OSA, although factors different from BMI and age (such as craniofacial characteristics) might still play a role. In our study, we found that patients with SDB had a significantly longer duration of receiving sedation in the ICU with higher cumulative doses of midazolam. Whether a preexisting SDB led to prolonged requirement of mechanical ventilation or SDB appeared as a result of prolonged sedation and higher doses of midazolam cannot be ascertained. Besides, the number of subjects with SDB in this study is too few for a definite conclusion.

We found low sleep efficiency (median 54%) in survivors of ARDS similar to the findings in previous studies.^[8,29,31] Further, most sleep occurred in stage 1 and 2 in our patients with markedly reduced restorative sleep (REM and slow wave sleep) as in previous reports.^[8,31] This again probably reflects the persistence of sleep abnormalities such as reduced REM and slow wave sleep that originate during the ICU stay.^[37] The finding

of a high prevalence (30%) of REM-related SDB in ARDS survivors needs further confirmation in a larger study cohort.

Our study has a few limitations including a small sample size. The study population mainly consists of predominantly young individuals with tropical illnesses as the cause of ARDS, thus the results may not be generalizable to other patient groups. We did not follow-up the patients over time; therefore, we cannot draw conclusions on whether the early changes in sleep quality lead to any symptomatic sleep disruption over a longer period of time. The strengths of our study include the prospective data collection in an unselected group of ARDS patients soon after discharge from the ICU.

Conclusions

Our study found a high prevalence of abnormal sleep in survivors of ARDS early after discharge from the ICU. The prevalence of sleep abnormalities found is lesser in studies performed late as compared to the early postdischarge period as is evident from the systematic review.

Acknowledgment

The authors fondly remember and heartily thank Late Prof. Dheeraj Gupta, Department of Pulmonary Medicine, Chandigarh, India, for overseeing this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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