Original Article

Relationship of sleep disturbance and postoperative delirium: a systematic review and meta-analysis

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Background: Studies have investigated the relationship between sleep disturbance and postoperative delirium (PD) but have controversial results. A systematic review and meta-analysis have a high level of evidence to comprehensively evaluate the effect of sleep disturbance on PD. Our study aims to provide available evidence regarding the effect of sleep disturbance on PD.

Methods: PubMed, Embase, Cochrane Library, and Web of Science databases were searched for relevant studies from database inception to April 28, 2021. The eligible studies were identified according to the "PICOS" principles. Odds ratio (OR) was used to indicate the effect index, and 95% confidence interval (CI) was applied to express the effect size. The heterogeneity was tested. Subgroup analyses, meta-regression, and sensitivity analysis were also applied. Begg's test was used to test potential publication bias. The modified Newcastle-Ottawa Scale (NOS) was used to evaluate the literature quality.

Results: Totally, 18 articles including 2,714 patients were enrolled, with most of the included literature being of moderate to high quality. The results of systematic and meta-analysis suggested that sleep disturbance was associated with an increased risk of PD (OR: 3.731; 95% CI: 2.338 to 5.956). Subgroup analysis results demonstrated that sleep disturbance in patients aged <65 years (OR: 6.072; 95% CI: 3.054 to 12.071), aged ≥65 years (OR: 2.904; 95% CI: 1.487 to 5.671), and undergoing cardiac (OR: 3.390; 95% CI: 1.359 to 8.453), orthopedic (OR: 3.943; 95% CI: 2.219 to 7.008), or other surgeries (OR: 4.963; 95% CI: 2.156 to 11.420) increased the risk of PD (all P<0.005). Moreover, increased risk of PD was found for both preoperative (OR: 2.804; 95% CI: 1.517 to 5.184) and postoperative (OR: 6.302; 95% CI: 3.794 to 10.467) sleep disturbance (all P<0.005). No associations between obstructive sleep apnea (OSA; OR: 2.008; 95% CI: 0.753 to 5.354; P=0.164), insomnia (OR: 4.005; 95% CI: 0.636 to 25.203; P=0.139) and risk of PD were observed.

Conclusions: Our study indicated the relationship between sleep disturbance and the risk of PD. Patients undergoing surgical treatments should pay attention to their sleep quality. However, more research is needed to confirm its relationship.

Keywords: Postoperative delirium (PD); sleep disturbance; systematic review; meta-analysis

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Introduction

Postoperative delirium (PD) is an acute but typically reversible syndrome that manifests as sudden and fluctuating changes in consciousness, attention, and cognition, affecting ranging from 11% to 51% of patients after major surgery (1,2). Increasing evidence has demonstrated both short-term and long-term poor prognoses in surgical patients who develop PD (3). PD is associated with longer hospital stays, increased mortality, and the long-term postoperative cognitive dysfunction, increasing economic burden on the healthcare systems (2,4). In practice, many patients with PD are not identified by doctors in time, which leads to delayed treatment measures and directly affects the patients' quality of life (5). Thereby, identifying modifiable risk factors and implementing risk reduction strategies may reduce the incidence of PD.

PD is the result of a combination of many factors, including advanced age, low education level, preoperative cognitive impairment, alcoholism, smoking, cardiac or vascular surgery, major non-cardiac surgery, perioperative use of sedative and analgesic drugs, postoperative incomplete analgesia, etc. (6,7). Sleep is currently a hot topic in clinical research due to its potential effects on cognitive function (8). Sleep is a regular physiological process of the human body, and the quality and quantity of sleep can affect the individual's health status and quality of life (9). Good sleep quality can help quickly eliminate fatigue, strengthen the immune effect, and maintain both physical strength and a healthy mental state (10). However, sleep disturbances are extremely common, becoming a global health concern (11). The disturbances include obstructive sleep apnea (OSA) and insomnia (12), which are associated with mental disorders (13,14). Several studies have shown that sleep disturbance may independently cause PD (15-17). However, the relationship between sleep disturbances and PD remains controversial. Previous studies by Roggenbach *et al.* and Wang *et al.* found that OSA was closely associated with PD (18,19). Nevertheless, there is a study obtaining no association between OSA and PD in the context of usual care in the intensive care unit (ICU) (20). Studies by de Rooij *et al.* (21) and Nguyen *et al.* (22) demonstrated insomnia was related to PD. Whereas, Wang *et al.* noticed that perioperative sleep disturbances were not potential risk factors for PD in randomized controlled trials (8). Systematic review and meta-analysis are the most commonly used research methods in evidence-based medicine. Meta-analysis is a statistical method that synthesizes a quantitative index from similar study groups with different results from multiple systematic reviews. The systematic review is a comprehensive summary of all relevant studies worldwide, with a strict evaluation of all included studies one by one, comprehensive analysis and evaluation of all research results, and meta-analysis if necessary (23). Combined with the results of all published studies, this study systematically evaluated the influence of sleep disturbance on PD, providing a basis for guiding the further discussion of PD. Subgroup analysis was performed for a more comprehensive assessment of sleep disturbance on PD in the meta-analysis. We present the following article in accordance with the MOOSE reporting checklist (available at https://gs.amegroups.com/article/view/10.21037/gs-22-312/rc).

Methods

Search strategy

A systematic search of PubMed, Embase, Cochrane Library and Web of Science databases for relevant articles was performed from database inception to April 28, 2021. The search terms were: "Confusion" OR "delirium" OR "delirious" AND "Sleep" OR "Sleep Disorder" OR "Sleep Wake Disorders" OR "dyssomn" OR "parasomn" OR "narcolep" OR "somnolen" OR "hypersomn" OR "insomnolen" OR "hyposomn" OR "hypnogenic paroxysmal" OR "somnamb".

Inclusion and exclusion criteria

Inclusion criteria were: (I) populations: patients undergoing surgical treatments; (II) observation: patients with PD after surgical treatments assigned to the case group; (III) control: patients without PD after surgical treatments assigned to the control group; (IV) outcomes: the relationship between sleep disturbance and PD; and the relationship between sleep disturbance and PD in different study types, age, sample size, operation type, type of sleep disturbance, occurrence time of sleep disturbance, and delirium assessment tools; (V) study design: cohort or case-control studies; (VI) English literature.

Exclusion criteria were: (I) animal experiments; (II) incomplete data or unable to be extracted; (III) abstracts, letters, editorials, protocols, case reports, reviews, and meta-analyses.

Methodological quality appraisal and data extraction

The modified Newcastle-Ottawa Scale (NOS) (24) was used to evaluate the literature quality, which comprises ten points that determine the selection, comparability, and exposure or outcome. There were four stars in the selection domain, two stars in the comparability domain, and three stars in the exposure or outcome domain. This scale has a total score of 10, with NOS scores >7 being considered high quality, and >5 being considered moderate quality.

Two researchers (Ertao He and Ying Dong) reviewed the identified literature and extracted study data according to the inclusion and exclusion criteria. Discrepancies were resolved through consultation with a third author (Haitao Jia). The following data were extracted from all included studies: name of the first author, year of publication, country of the study, study design, type of surgery, number of participants, mean age (years), sex, number of patients with PD after surgical treatment, type of sleep disturbance, timing of sleep disturbance, sleep quality assessment tool, delirium assessment tool, quality assessment.

Statistical analysis

All studies were statistically analyzed using Stata15.1 software (Stata Corporation, College Station, TX, USA). Odds ratio (OR) was used as the effect indicator, and the 95% confidence interval (CI) was applied to express the effect size. Heterogeneity was tested; for the heterogeneity statistic $I^2 \geq 50\%$, random-effect model analysis was performed, otherwise, fixed-effect model analysis was applied. To investigate the high degree of heterogeneity, subgroup analyses were based on study type, age, sample size, type of surgery, type of sleep disturbance, the timing of sleep disturbance, and delirium assessment tool. In addition, meta-regression was used to explore the source of heterogeneity. Sensitivity analysis was performed for all models, and Begg's test was used to test potential publication bias. $P<0.05$ was considered statistically significant. All reported P values are two-sided.

Results

Study selection and characteristics of included studies

After the English databases were searched according to the retrieval strategy, a total of 6,827 articles were identified. After duplicates were removed, 3,865 studies remained, and of them, 38 studies were screened for titles and abstracts. Finally, 18 articles (16-18,25-39) including 2,714 patients were enrolled, comparing 16 articles in the quantitative analysis, and 2 in the qualitative analysis. A summary of the search and selection process is depicted in *Figure 1*. Most of the included studies were of moderate to high quality (Table S1): 5 studies retrospective studies, and 11 prospective studies. Patients in 7 studies were undergoing cardiac surgery, in 5 studies they were undergoing orthopedic surgery, and in 4 studies it was other procedures. The sample size of 5 articles was <100, and that of 11 studies was ≥100. According to the type of sleep disturbance, patients were divided into 5 cases of OSA, 2 cases of insomnia, and 9 cases that did not indicate the specific type. There were 11 cases of sleep disturbance before surgery and 5 cases after surgery. The characteristics of included studies are listed in *Tables 1,2*.

Pooled analysis of effect of sleep disturbance on PD

Yildizeli *et al.* (26) reported that among the risk factors associated with PD after thoracic surgery, the factors influencing PD by univariate analysis included sleep disturbance (P=0.008). Jeong *et al.* (32) studied the risk factors for delirium in 247 prostate surgery patients and found that sleep disturbance was not significantly associated with the occurrence of PD (OR: 0.88; 95% CI: 0.3 to 2.6; P=0.811).

A total of 16 studies were included in the meta-analysis for quantitative analysis, and the heterogeneity test showed $I^2=60.7\%$, so a random-effect model was used. The result suggested that sleep disturbance was associated with an increased risk of PD (OR: 3.73; 95% CI: 2.34 to 5.96; P<0.001) (*Table 3*, *Figure 2*).

Subgroup analysis of effect of sleep disturbance on PD

Study design

The result for study design demonstrated that sleep disturbance increased the risk of PD in both retrospective (OR: 5.74; 95% CI: 3.04 to 10.84; P<0.001) and prospective studies (OR: 3.21; 95% CI: 1.77 to 5.81; P<0.001) (*Table 3*, *Figure 3A*).

Age

Based on the mean age of the patients enrolled in the analysis, they were divided into <65 (6 articles) and ≥65 years (9 articles). The result showed sleep disturbance was associated with PD with OR: 6.07 (95% CI: 3.05 to 12.07; P<0.001) in patients <65 years, and OR= 2.90, (95% CI: 1.49 to 5.67, P=0.002) in patients ≥65 years (*Table 3*, *Figure 3B*).

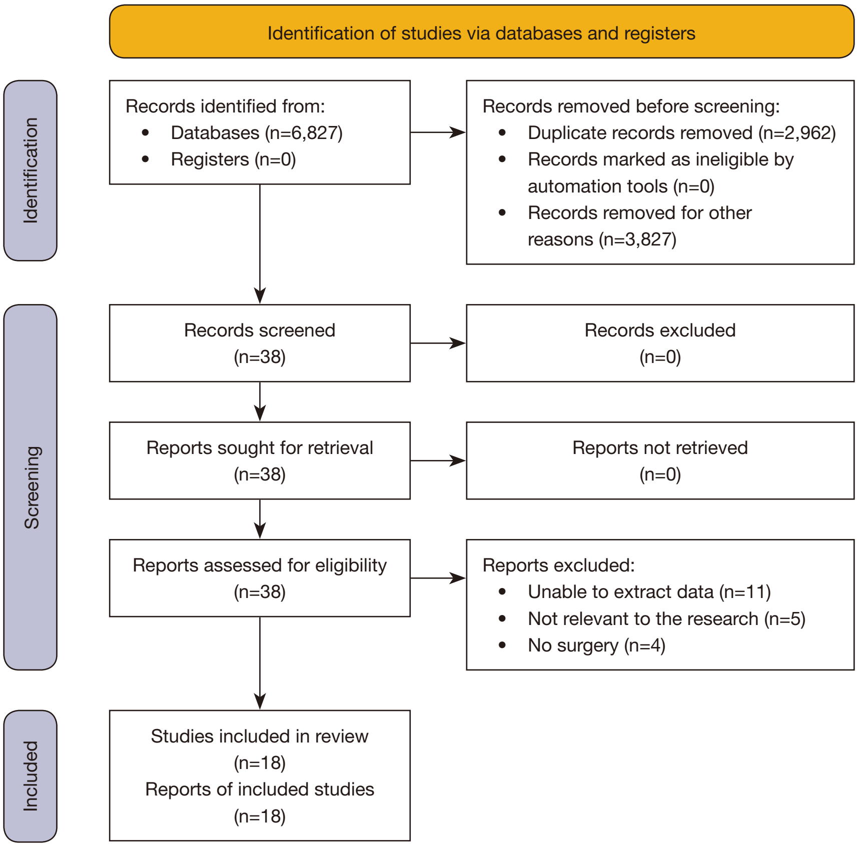

Figure 1 Summary of the search and selection process.

Sample size

Results from the sample size analysis showed that no matter the sample size [<100 (OR: 3.93; 95% CI: 1.16 to 13.28; P=0.028); ≥100 (OR: 3.72; 95% CI: 2.21 to 6.26; P<0.001)], there was a high risk of PD in patients with sleep disturbance (*Table 3*, *Figure 3C*).

Type of surgery

In this study sleep disturbance was a potential risk factor for PD in patients undergoing cardiac (OR: 3.39; 95% CI: 1.36 to 8.45; P=0.009), orthopedic (OR: 3.94; 95% CI: 2.22 to 7.01; P<0.001), or other surgeries (OR: 4.96; 95% CI: 2.16 to 11.42; P<0.001) (*Table 3*, *Figure 3D*).

Type of sleep disturbance

Our analysis showed that OSA (OR: 2.01; 95% CI: 0.75 to 5.35; P=0.164) and insomnia (OR: 4.01; 95% CI: 0.64 to 25.20; P=0.139) were not risk factors for PD (*Table 3*, *Figure 3E*).

Timing of sleep disturbance

The result of our analysis indicated that both preoperative (OR: 2.80; 95% CI: 1.52 to 5.18; P=0.001) and postoperative (OR: 6.30; 95% CI: 3.79 to 10.47; P<0.001) sleep disturbances was associated with the risk of PD (*Table 3*, *Figure 3F*).

Delirium assessment tool

According to the delirium assessment tool used in the research, the Confusion Assessment Method (CAM) was used in 11 articles, the Diagnostic and Statistical Manual of Mental Disorders, 4th ed. (DSM-IV) was used in 2 articles, and other tools were using in the remaining 3 articles. Sleep disturbance was a risk factor for PD no matter which delirium assessment tool was used: CAM (OR: 3.72; 95% CI: 2.00 to 6.92; P<0.001), DSM-IV (OR: 5.40; 95% CI: 1.60 to 18.25; P=0.007), and other tools (OR: 3.02; 95% CI: 1.22 to 7.48; P=0.017) (*Table 3*, *Figure 3G*).

Table 1 Baseline characteristics of included studies

Study	Country	Study design	Type of surgery	N	Mean age (y)	Sex (M/F)	No. of deliriums	Type of sleep disturbance	Timing of sleep disturbance	Sleep quality assessment tool	Delirium assessment tool	Quality assessment
Gupta *et al.*, 2001	USA	Retrospective case-control	Orthopedic	202	68.1	140/62	13	OSA	Preoperative	None	Stated by caregivers	9
Yildizeli *et al.*, 2005	Turkey	Retrospective cohort	Thoracic	432	51.7	291/141	23	Sleep deprivation	Postoperative (before delirium)	None	DSM-IV	9
Koster *et al.*, 2009	Netherlands	Prospective cohort	Cardiac	103	–	–	19	Not specified	Postoperative (after delirium)	None	DSM-IV	6
Flink *et al.*, 2012	USA	Prospective cohort	Orthopedic	106	73.3	47/59	27	OSA	Preoperative	Polysomnography or use of continuous positive airway pressure	CAM, DRS-R-98, DSM-IV, patient chart records	9
Roggenbach *et al.*, 2014	Germany	Prospective cohort	Cardiac	92	67.5	66/26	44	OSA	Preoperative	AHI using nocturnal readings from portable polygraphy	CAM for ICU	9
Leung *et al.*, 2015	USA	Prospective cohort	Non-cardiac	50	66	26/24	7	OSA	Preoperative	PSQI, GSDS, sleep diary	CAM	8
Wang *et al.*, 2015	China	Retrospective cohort	Orthopedic	200	65	95/105	17	Not specified	Postoperative (before delirium)	None	CAM	8
Zhang *et al.*, 2015	China	Prospective cohort	Cardiac	249	62.9	197/52	76	Not specified	Postoperative (before delirium)	None	CAM	8
Jeong *et al.*, 2016	South Korea	Retrospective cohort	Thoracic	247	–	229/18	93	Not specified	Preoperative	None	CAM	7
Cheraghi *et al.*, 2016	Iran	Prospective cohort	Cardiac	40	59.19	24/16	9	Not specified	Preoperative	PSQI	CAM for ICU	8
Todd *et al.*, 2017	Germany	Prospective cohort	Orthopedic	101	76	28/73	27	Not specified	Preoperative	PSQI, WASO	CAM	9
Bosmak *et al.*, 2017	Brazil	Retrospective cohort	Orthopedic	56	63	23/33	5	Not specified	Preoperative	None	Patient chart records	8
Kim *et al.*, 2018	South Korea	Prospective cohort	Spinal	104	71.7	36/68	15	Insomnia	Preoperative	ISI, ESS	CAM	7
Makiguchi *et al.*, 2018	Japan	Retrospective cohort	Oral cancer resection	102	59.6	69/33	34	Insomnia	Postoperative (before delirium)	None	DSM-IV	7
Tafelmeier *et al.*, 2019	Germany	Prospective cohort	Cardiac	141	68	123/18	33	OSA	Preoperative	None	CAM for ICU	8
Chen *et al.*, 2020	China	Prospective cohort	Cardiac	20	51.7	11/9	8	Not specified	Postoperative (before delirium)	Sleep monitoring	CAM for ICU	7
Cho *et al.*, 2020	South Korea	Retrospective cohort	Fracture	283	78.73	80/203	48	Not specified	Preoperative	PSQI	CAM	5
Wang *et al.*, 2020	China	Prospective cohort	Cardiac	186	53.6	105/81	29	Not specified	Preoperative	PSQI	CAM for ICU	6

OSA, obstructive sleep apnea; AHI, Apnea-Hypopnea Index; PSQI, Pittsburgh Sleep Quality Index; GSDS, General Sleep Disturbance Scale; WASO, Wake After Sleep Onset; ISI, Insomnia Severity Index; ESS, Epworth Sleepiness Scale; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, 4th ed.; CAM, Confusion Assessment Method; DRS-R-98, Delirium Rating Scale-Revised-98; ICU, intensive care unit.

Table 2 Outcomes of included studies

Study	Year	Country	Case: PD			Control: no PD		
			All	With sleep disturbance	Without sleep disturbance	All	With sleep disturbance	Without sleep disturbance
Gupta *et al.*	2001	USA	13	10	3	189	91	98
Koster *et al.*	2009	Netherlands	19	9	10	84	20	64
Flink *et al.*	2012	USA	27	8	19	79	7	72
Roggenbach *et al.*	2014	Germany	44	41	3	48	42	6
Leung *et al.*	2015	USA	7	3	4	43	8	35
Wang *et al.*	2015	China	17	14	3	183	84	99
Zhang *et al.*	2015	China	76	36	40	173	21	152
Cheraghi *et al.*	2016	Iran	9	8	1	31	11	20
Todd *et al.*	2017	Germany	27	22	5	74	36	38
Bosmak *et al.*	2017	Brazil	5	1	4	51	15	36
Kim *et al.*	2018	South Korea	15	5	10	89	22	67
Makiguchi *et al.*	2018	Japan	34	27	7	68	19	49
Tafelmeier *et al.*	2019	Germany	33	5	28	108	32	76
Chen *et al.*	2020	China	8	7	1	12	2	10
Cho *et al.*	2020	South Korea	48	36	12	235	65	170
Wang *et al.*	2020	China	29	23	6	157	83	74

PD, postoperative delirium.

Meta-regression analysis

To explore the source of heterogeneity, meta-regression was performed by study type, age, sample size, type of surgery, type of sleep disturbance, time of occurrence of sleep disturbance, and delirium assessment tool. The results showed that none of these factors was related to inter-study heterogeneity (P>0.05) (*Table 4*).

Sensitivity analysis and publication bias

Sensitivity results demonstrated that our study was robust and reliable. Publication bias was assessed using Begg's test, which showed no publication bias in this pooled analysis (Z=0.14; P=0.893) (*Table 3*).

Discussion

PD can occur in any surgical patient and its occurrence has adverse effects on the prognosis of postoperative patients (40). Thus, it may be useful to identify potential influential factors. Our analyses demonstrated that in different age groups, and for various types of surgery, both preoperative and postoperative sleep disturbance increased the risk of PD. However, further subgroup analysis suggested that these findings were not conserved for OSA and insomnia as types of sleep disturbance.

A study by Evans *et al.* found that sleep disturbance on the first night after surgery was a predictor of subsequent delirium (41). Sleep polysomnographic measurements were taken the night before surgery in elderly hospitalized patients scheduled for elective major cardiac surgery and cardiopulmonary bypass suggest an association between longer sleep duration and PD (42). A study that recruited referrals with aortic stenosis undergoing first lifetime surgical aortic valve replacement reported that type II home sleep studies were a predictor of PD (15). Wang *et al.* found hospitalized sleep disturbances increased the incidence of PD (43). Another study demonstrated that reducing sleep disturbances in an ICU significantly reduced delirium in medical and surgical intensive care patients (44). Lu *et al.*

Table 3 Overall results and sensitivity analysis

Outcomes	Indicator	OR (95% CI)	P	I^2
Pooled analysis	Overall	3.73 (2.34, 5.96)	<0.001	60.7
	Sensitivity analysis	3.73 (2.34, 5.96)		
	Publication bias	Z=0.14	0.893	
Subgroup analysis				
Study design	Retrospective study	5.74 (3.04, 10.84)	<0.001	34.2
	Prospective study	3.21 (1.77, 5.81)	<0.001	63.3
Age (years)	<65	6.07 (3.05, 12.07)	<0.001	43.0
	≥65	2.90 (1.49, 5.67)	0.002	66.9
Sample size	<100	3.93 (1.16, 13.28)	0.028	47.4
	≥100	3.72 (2.21, 6.26)	<0.001	67.1
Type of surgery	Cardiac surgery	3.39 (1.36, 8.45)	0.009	76.0
	Orthopedic surgery	3.94 (2.22, 7.01)	<0.001	0.0
	Other surgery	4.96 (2.16, 11.42)	<0.001	58.6
Type of sleep disturbance	OSA	2.01 (0.75, 5.35)	0.164	65.0
	Insomnia	4.01 (0.64, 25.20)	0.139	82.6
	Not specified	5.26 (3.48, 7.95)	<0.001	21.2
Timing of sleep disturbance	Preoperative	2.80 (1.52, 5.18)	0.001	63.4
	Postoperative	6.30 (3.79, 10.47)	<0.001	16.4
Delirium assessment tool	CAM	3.72 (2.00, 6.92)	<0.001	68.5
	DSM-IV	5.40 (1.60, 18.25)	0.007	65.7
	Other tools	3.02 (1.22, 7.48)	0.017	16.9

OSA, obstructive sleep apnea; CAM, Confusion Assessment Method; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, 4th ed.; OR, odds ratio; CI, confidence interval.

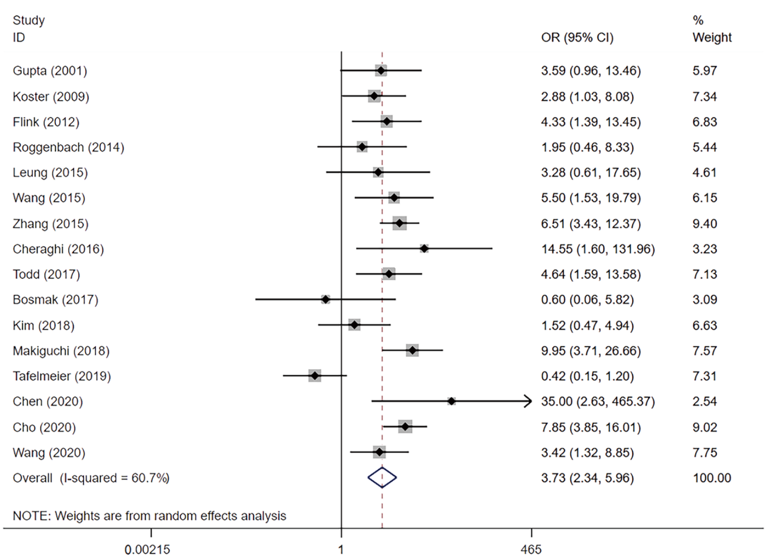

Figure 2 Forest plot of pooled analysis. OR, odds ratio; CI, confidence interval.

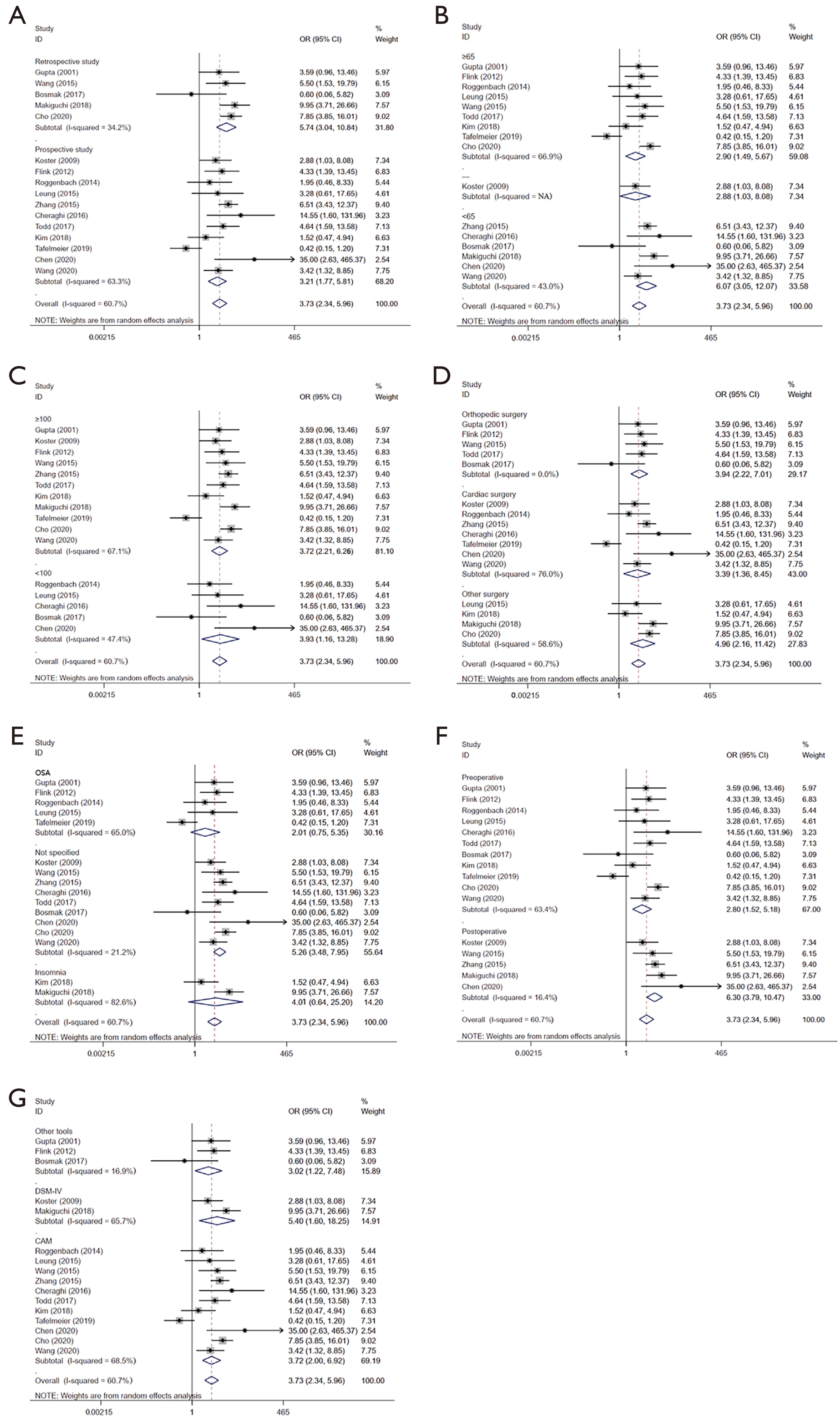

Figure 3 Forest plots of subgroup analyses: (A) study design; (B) age; (C) sample size; (D) type of surgery; (E) type of sleep disturbance; (F) timing of sleep disturbance; (G) delirium assessment tool. OR, odds ratio; CI, confidence interval.

Table 4 Meta-regression results

Variables	Coeff.	SE	t	P	95% CI	
					Lower	Upper
Study design						
Retrospective	Ref.					
Prospective	2.722	8.040	0.34	0.749	−17.946	23.389
Age (years)						
<65	Ref.					
≥65	−2.939	6.492	−0.45	0.670	−19.627	13.749
Sample size						
<100	Ref.					
≥100	−5.265	6.503	−0.81	0.455	−21.980	11.451
Type of surgery						
Cardiac	Ref.					
Orthopedic	−1.550	10.614	−0.15	0.890	−28.835	25.734
Other	2.868	10.570	0.27	0.797	−24.303	30.040
Type of sleep disturbance						
OSA	Ref.					
Insomnia	0.119	14.618	0.01	0.994	−37.457	37.695
Not specified	2.440	7.552	0.32	0.760	−16.972	21.852
Timing of sleep disturbance						
Preoperative	Ref.					
Postoperative	10.653	8.000	1.33	0.240	−9.908	31.214
Delirium assessment tool						
CAM	Ref.					
DSM-IV	−5.811	12.298	−0.47	0.656	−37.425	25.803
Other tools	2.464	11.789	0.21	0.843	−27.840	32.769
Constant	8.639	14.893	0.58	0.587	−29.645	46.924

OSA, obstructive sleep apnea; CAM, Confusion Assessment Method; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, 4th ed.; Coeff., coefficient; Ref., reference group; SE, standard error; CI, confidence interval.

found that strategies targeted at sleep promotion might help prevent PD (2), and Cho *et al.* found sleep disturbance strongly related to the development of PD in proximal femoral fracture patients aged 60 years or older (38). The exact mechanism connecting sleep disturbance and PD is still not well understood. Activated neuroinflammation and oxidative stress, impaired function of the blood-brain barrier and glymphatic pathway, decreased hippocampal brain-derived neurotrophic factor, adult neurogenesis, and sirtuin1 expression, as well as accumulated amyloid-beta proteins may be associated with PD in individuals with perioperative sleep disturbance (43). Because of the relationship between sleep quality and PD, the use of sleep deprivation prevention programs in hospital clinical nursing instruction may be critical.

Sleep-disordered breathing is rarely considered a potential risk factor for PD (18). Consistent with our finding, Wang *et al.* found no association between preoperative OSA, which is the most prevalent form of sleep-disordered breathing, and delirium prevalence (19). King *et al.* found that, after risk adjustment, there was no significant association between OSA and PD (20). However, a case report by Lombardi *et al.* independently published reports found that treatment for OSA was successful in alleviating delirium (45). It is important to note that case reports cannot exclude other predisposing factors; therefore, it is difficult to draw definitive conclusions about the relationship between OSA and delirium. Furthermore, OSA could be a less important risk factor for PD than previously believed. The literature draws a somewhat tenuous connection between OSA and postoperative adverse outcomes, with some studies finding (unadjusted) negative associations (20,46). The association between OSA and PD should be further studied with adjustment for confounding factors.

In a large-sample study, Martin *et al.* showed that individuals who developed PD after cardiac surgery had a greater future risk for stroke and death (47). Therefore, delirium should be approached as a disorder and given full attention. Given our finding of the relationship between sleep disturbance and the risk of PD, clinicians should advise patients and their families to actively cooperate with any sleep intervention before and after surgery. If they understand the positive effect of adequate sleep on disease treatment and rehabilitation, patients will be encouraged to establish good sleep habits.

There were some important limitations to this study. First, we did not control for environmental determinants of sleep such as noise or light, and anesthetic use due to limitations in the included studies. Second, the literature search has language bias since no non-English language databases were searched. Third, most of the included studies used "cases that did not indicate the specific type" to describe the sleep disturbance, making the clinical implications of the significant association between PD and sleep disturbance difficult. Large-scale investigations including more patients should be performed to further verify the effect of sleep disturbance on PD. Despite the limitations of this study, the results encourage future research aimed at addressing the above limitations and confirming or refuting the effects of sleep disturbance on PD.

Conclusions

Our results demonstrated that sleep disturbance may increase the risk of PD. The quality of sleep in patients undergoing surgery should be given attention. More research is needed to confirm the effect of sleep disturbance on PD.

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Footnote

Reporting Checklist: The authors have completed the MOOSE reporting checklist. Available at https://gs.amegroups.com/article/view/10.21037/gs-22-312/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://gs.amegroups.com/article/view/10.21037/gs-22-312/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

References

1. Avidan MS, Maybrier HR, Abdallah AB, et al. Intraoperative ketamine for prevention of postoperative delirium or pain after major surgery in older adults: an international, multicentre, double-blind, randomised clinical trial. Lancet 2017;390:267-75.
2. Lu Y, Li YW, Wang L, et al. Promoting sleep and circadian health may prevent postoperative delirium: A systematic review and meta-analysis of randomized clinical trials. Sleep Med Rev 2019;48:101207.
3. Shi Z, Mei X, Li C, et al. Postoperative Delirium Is Associated with Long-term Decline in Activities of Daily Living. Anesthesiology 2019;131:492-500.
4. Saczynski JS, Marcantonio ER, Quach L, et al. Cognitive

trajectories after postoperative delirium. N Engl J Med 2012;367:30-9.
5. Mufti HN, Hirsch GM, Abidi SR, et al. Exploiting Machine Learning Algorithms and Methods for the Prediction of Agitated Delirium After Cardiac Surgery: Models Development and Validation Study. JMIR Med Inform 2019;7:e14993.
6. Kong D, Luo W, Zhu Z, et al. Factors associated with post-operative delirium in hip fracture patients: what should we care. Eur J Med Res 2022;27:40.
7. Assefa S, Sahile WA. Assessment of Magnitude and Associated Factors of Emergence Delirium in the Post Anesthesia Care Unit at Tikur Anbesa Specialized Hospital, Ethiopia. Ethiop J Health Sci 2019;29:597-604.
8. Wang H, Zhang L, Zhang Z, et al. Perioperative Sleep Disturbances and Postoperative Delirium in Adult Patients: A Systematic Review and Meta-Analysis of Clinical Trials. Front Psychiatry 2020;11:570362.
9. Gao T, Wang Z, Dong Y, et al. Role of melatonin in sleep deprivation-induced intestinal barrier dysfunction in mice. J Pineal Res 2019;67:e12574.
10. Azevedo Da Silva M, Singh-Manoux A, Shipley MJ, et al. Sleep duration and sleep disturbances partly explain the association between depressive symptoms and cardiovascular mortality: the Whitehall II cohort study. J Sleep Res 2014;23:94-7.
11. Liu X, Chen J, Zhou J, et al. The Relationship between the Number of Daily Health-Related Behavioral Risk Factors and Sleep Health of the Elderly in China. Int J Environ Res Public Health 2019;16:4905.
12. Whitesell PL, Obi J, Tamanna NS, et al. A Review of the Literature Regarding Sleep and Cardiometabolic Disease in African Descent Populations. Front Endocrinol (Lausanne) 2018;9:140.
13. Scullin MK, Bliwise DL. Sleep, cognition, and normal aging: integrating a half century of multidisciplinary research. Perspect Psychol Sci 2015;10:97-137.
14. Yaffe K, Nettiksimmons J, Yesavage J, et al. Sleep Quality and Risk of Dementia Among Older Male Veterans. Am J Geriatr Psychiatry 2015;23:651-4.
15. Oldham MA, Pigeon WR, Chapman B, et al. Baseline sleep as a predictor of delirium after surgical aortic valve replacement: A feasibility study. Gen Hosp Psychiatry 2021;71:43-6.
16. Kim KH, Kang SY, Shin DA, et al. Parkinson's disease-related non-motor features as risk factors for post-operative delirium in spinal surgery. PLoS One 2018;13:e0195749.
17. Todd OM, Gelrich L, MacLullich AM, et al. Sleep Disruption at Home As an Independent Risk Factor for Postoperative Delirium. J Am Geriatr Soc 2017;65:949-57.
18. Roggenbach J, Klamann M, von Haken R, et al. Sleep-disordered breathing is a risk factor for delirium after cardiac surgery: a prospective cohort study. Crit Care 2014;18:477.
19. Wang S, Sigua NL, Manchanda S, et al. Preoperative STOP-BANG Scores and Postoperative Delirium and Coma in Thoracic Surgery Patients. Ann Thorac Surg 2018;106:966-72.
20. King CR, Fritz BA, Escallier K, et al. Association Between Preoperative Obstructive Sleep Apnea and Preoperative Positive Airway Pressure With Postoperative Intensive Care Unit Delirium. JAMA Netw Open 2020;3:e203125.
21. de Rooij SE, van Munster BC. Melatonin deficiency hypothesis in delirium: a synthesis of current evidence. Rejuvenation Res 2013;16:273-8.
22. Nguyen PV, Pelletier L, Payot I, et al. The Delirium Drug Scale is associated to delirium incidence in the emergency department. Int Psychogeriatr 2018;30:503-10.
23. He Y, Wang R, Wang F, et al. The clinical effect and safety of new preoperative fasting time guidelines for elective surgery: a systematic review and meta-analysis. Gland Surg 2022;11:563-75.
24. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol 2010;25:603-5.
25. Gupta RM, Parvizi J, Hanssen AD, et al. Postoperative complications in patients with obstructive sleep apnea syndrome undergoing hip or knee replacement: a case-control study. Mayo Clin Proc 2001;76:897-905.
26. Yildizeli B, Ozyurtkan MO, Batirel HF, et al. Factors associated with postoperative delirium after thoracic surgery. Ann Thorac Surg 2005;79:1004-9.
27. Koster S, Hensens AG, van der Palen J. The long-term cognitive and functional outcomes of postoperative delirium after cardiac surgery. Ann Thorac Surg 2009;87:1469-74.
28. Flink BJ, Rivelli SK, Cox EA, et al. Obstructive sleep apnea and incidence of postoperative delirium after elective knee replacement in the nondemented elderly. Anesthesiology 2012;116:788-96.
29. Leung JM, Sands LP, Newman S, et al. Preoperative Sleep Disruption and Postoperative Delirium. J Clin Sleep Med 2015;11:907-13.
30. Wang J, Li Z, Yu Y, et al. Risk factors contributing to postoperative delirium in geriatric patients postorthopedic

surgery. Asia Pac Psychiatry 2015;7:375-82.
31. Zhang WY, Wu WL, Gu JJ, et al. Risk factors for postoperative delirium in patients after coronary artery bypass grafting: A prospective cohort study. J Crit Care 2015;30:606-12.
32. Jeong DM, Kim JA, Ahn HJ, et al. Decreased Incidence of Postoperative Delirium in Robot-assisted Thoracoscopic Esophagectomy Compared With Open Transthoracic Esophagectomy. Surg Laparosc Endosc Percutan Tech 2016;26:516-22.
33. Cheraghi MA, Hazaryan M, Bahramnezhad F, et al. Study of the relationship between sleep quality and prevalence of delirium in patients undergoing cardiac surgery. World Journal of Medical Sciences 2016;13:60-4.
34. Bosmak FS, Gibim PT, Guimarães S, et al. Incidence of delirium in postoperative patients treated with total knee and hip arthroplasty. Rev Assoc Med Bras (1992) 2017;63:248-51.
35. Makiguchi T, Yokoo S, Kurihara J. Risk factors for postoperative delirium in patients undergoing free flap reconstruction for oral cancer. Int J Oral Maxillofac Surg 2018;47:998-1002.
36. Tafelmeier M, Knapp M, Lebek S, et al. Predictors of delirium after cardiac surgery in patients with sleep disordered breathing. Eur Respir J 2019;54:1900354.
37. Chen Q, Peng Y, Lin Y, et al. Atypical Sleep and Postoperative Delirium in the Cardiothoracic Surgical Intensive Care Unit: A Pilot Prospective Study. Nat Sci Sleep 2020;12:1137-44.
38. Cho MR, Song SK, Ryu CH. Sleep Disturbance Strongly Related to the Development of Postoperative Delirium in Proximal Femoral Fracture Patients Aged 60 or Older. Hip Pelvis 2020;32:93-8.
39. Wang H, Zhang L, Luo Q, et al. Effect of Sleep Disorder on Delirium in Post-Cardiac Surgery Patients. Can J Neurol Sci 2020;47:627-33.
40. Inouye SK, Westendorp RG, Saczynski JS. Delirium in elderly people. Lancet 2014;383:911-22.
41. Evans JL, Nadler JW, Preud'homme XA, et al. Pilot prospective study of post-surgery sleep and EEG predictors of post-operative delirium. Clin Neurophysiol 2017;128:1421-5.
42. Ibala R, Mekonnen J, Gitlin J, et al. A polysomnography study examining the association between sleep and postoperative delirium in older hospitalized cardiac surgical patients. J Sleep Res 2021;30:e13322.
43. Wang X, Hua D, Tang X, et al. The Role of Perioperative Sleep Disturbance in Postoperative Neurocognitive Disorders. Nat Sci Sleep 2021;13:1395-410.
44. Patel J, Baldwin J, Bunting P, et al. The effect of a multicomponent multidisciplinary bundle of interventions on sleep and delirium in medical and surgical intensive care patients. Anaesthesia 2014;69:540-9.
45. Lombardi C, Rocchi R, Montagna P, et al. Obstructive sleep apnea syndrome: a cause of acute delirium. J Clin Sleep Med 2009;5:569-70.
46. Opperer M, Cozowicz C, Bugada D, et al. Does Obstructive Sleep Apnea Influence Perioperative Outcome? A Qualitative Systematic Review for the Society of Anesthesia and Sleep Medicine Task Force on Preoperative Preparation of Patients with Sleep-Disordered Breathing. Anesth Analg 2016;122:1321-34.
47. Martin BJ, Buth KJ, Arora RC, et al. Delirium: a cause for concern beyond the immediate postoperative period. Ann Thorac Surg 2012;93:1114-20.

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