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ORIGINAL ARTICLE

Prevalence, correlates, and impact of sleep disturbance in Chinese meningioma patients

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Abstract

Purpose Sleep disturbance is common in meningioma patients and may lead to disease aggravation and decreases health-related quality of life (HRQoL). However, the sleep quality of meningioma patients newly diagnosed and ready for surgery has not been well clarified in China. This study aims to evaluate the prevalence, correlates, and impact of sleep disturbance among Chinese meningioma patients.

Methods In this cross-sectional study, meningioma patients were recruited from the Affiliated Hospital of Nantong University from January 2020 to November 2020. A series of questionnaires were applied: the 0–10 Numerical Rating Scale (NRS), the Hospital Anxiety and Depression Scale (HADS), the Multidimensional Fatigue Inventory (MFI-20), the Epworth Sleepiness Scale (ESS), the Short-Form 36 (SF-36), the Pittsburgh Sleep Quality Index (*PSQI*). Independent samples *t* test, Mann–Whitney *U* test, chi-square analysis, Pearson/Spearman correlation, and binary logistic regression were used to analyze the data.

Results One hundred meningioma patients completed the questionnaires. Sleep disturbance affected 43% of the meningioma patients and was linked to many concomitant symptoms, such as headache, fatigue, anxiety, and depression. Binary logistic regression indicated that fatigue and headache were independently associated with sleep disturbance of meningioma patients. Meanwhile, severe sleep disturbance led to lower quality of life.

Conclusions These findings demonstrated that a considerable number of meningioma patients newly diagnosed and ready for surgery suffered from sleep disturbance, potentially contributing to impair HRQoL. Medical personnel should pay more attention to meningioma patients with sleep disturbance and take effective measures to improve sleep quality, with the ultimate goal to improve their HRQoL.

Keywords Meningioma · Sleep quality · Quality of life · Fatigue · Headache

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Introduction

Meningiomas assumed to originate from arachnoid cap cells are the most common benign intracranial tumors of the central nervous system, accounting for 36.6% of all intracranial tumors [1]. About 80% of meningiomas are benign (WHO grade I) with slow-growing rate and have a favorable long-term prognosis [1]. The other 20% of meningiomas are biologically invasive (WHO grade II and WHO grade III) with faster-growing rate and are more likely to invade the brain [1, 2]. Owing to local mass effect and brain edema, patients may suffer from a wide variety of physical and mental symptoms, such as epilepsy, visual loss, difficulty speaking, cognitive impairment, psychiatric symptoms, and neurological deficits [3–6]. In addition, the majority of patients suffer from more general symptoms, such as headache, fatigue, anxiety, depression, and sleep disturbance [7, 8]. Both the disease-specific and more general symptoms may cause limitations of daily activities, which eventually leads to the deterioration of patients' health-related quality of life (HRQoL).

Sleep is a complex neurological process and one of the most important physiological requirements for humans, which is closely related to immune system function, mental health, cognitive functioning, and quality of life [9–12]. Sleep disturbance can disrupt the physical and psychological well-being of patients. These patients will have pain sensitivity, memory and attention deficits, and deterioration of psychosocial functioning, thus impacting on patients' quality of life [13]. Several parts of the brain areas associated with sleep, in particular the hypothalamus, the brainstem, and the basal forebrain. The lesions in these areas are caused by the local and regional effects of brain tumors or their treatment, which can produce sleep disturbance [14]. Sleep disturbance is a very common symptom in patients with brain tumor (BT), and occurs at any point during the BT trajectory [15]. Unfortunately, although sleep disturbance is common in these patients, the problem has largely been ignored. Especially for meningioma patients, there is a limited number of studies related to sleep disturbance, which have some limitations. First, some of these studies included a broad range of brain tumors types, not just meningiomas [16, 17]. Second, some studies included only a limited assessment of sleep disturbance, relying on a single-question format or as part of a general symptom inventory, and did not investigate other manifestations of sleep disturbance [18, 19]. Third, the sample size included in the study was limited [16]. Lastly, the incidence and correlates of sleep disturbance have not been clearly defined among meningioma patients. As a common symptom in meningioma patients, sleep disturbance has not previously been explored among meningioma patients newly diagnosed and ready for surgery in China.

To address these issues, we conducted the first study, to our knowledge, of sleep disturbance in Chinese meningioma patients newly diagnosed and ready for surgery. The aims of our study are (1) to explore the sleep quality of meningioma patients, (2) to determine correlates of sleep disturbance in meningioma patients, and (3) to investigate the correlation between sleep quality and the quality of life in meningioma patients.

Methods

Participants

Patients were recruited from the Affiliated Hospital of Nantong University from January 2020 to November 2020. All patients completed self-report questionnaires the day before surgery, with a histologically confirmed intracranial meningioma postoperatively. Subjects who met any of the following criteria were excluded: (1) they were less than 18 years old; (2) severe hepatic, hematological, cardiovascular, renal, or other diseases that restricted daily activity and impaired quality of life; (3) patients with psychiatric disorders or severe cognitive impairment, and cannot cooperate with the completion of the questionnaire. A total of 103 meningioma patients from the inpatient ward of the Department of neurosurgery were invited to participate in this study. Three patients were excluded because they did not fully complete the provided questionnaires. Eventually, 100 meningioma patients were enrolled in the cross-sectional study. This study was approved by the Ethics Committee of the Affiliated Hospital of Nantong University (number:2020-K042). All participants completed the questionnaire on a voluntary basis and written informed consent was obtained from all subjects, according to the Declaration of Helsinki.

Demographic and clinical characteristics

Demographic variables include age, gender, body mass index (BMI), place of residence, marital status, education level, occupation, annual per capita income, medical insurance, tobacco use, alcohol use, menopausal status, and physical exercise, which were obtained by a self-designed questionnaire.

Clinical variables include time since diagnosis, comorbidity (this variable just indicates that the patient had at least one comorbid condition of any type, such as hypertension and diabetes), initial presenting symptoms, functional status (Karnofsky performance scale (KPS) score), tumor size (which was measured as the maximum

diameter), lateralization, location, and WHO grade, which were obtained by asking patients or viewing their electronic medical records.

Self-reported questionnaires

Headache was measured by a 0–10 Numerical Rating Scale (NRS) to characterize headache intensity. Patients were asked to rate their average pain intensity during the last week by selecting a single number from 0 to 10, 0 on the NRS indicated "no pain at all" and 10 on the NRS indicated "the worst imaginable pain" [20]. The NRS was recommended by Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT) and Cronbach's alpha for the NRS was reported as 0.89[21].

The Hospital Anxiety and Depression Scale (HADS) was the most frequently applied measure for research purposes in neuro-oncology setting and was recommended for initial depression screening in brain tumor patients[22]. It consists of 14 items, seven per subscale. Each item had a 4-point Likert scale and was scored between 0 and 3. Scores for each subscale were constructed by summation, ranging $0-21$. Patients scoring 8 or above in any of the scales are classified as clinically relevant anxiety and depression respectively. The Chinese version of the HADS in the current study confirmed sound internal consistency (Cronbach's alpha for HADS-A = 0.75 and HADS-D = 0.76)[23].

Fatigue was assessed using the Multidimensional Fatigue Inventory (MFI-20)[24], which is a widely used multidimensional questionnaire with adequate psychometric quality[25]. The MFI-20 contains a total of 20 items, including general fatigue, physical fatigue, reduced activity, reduced motivation, and mental fatigue. Each content has 4 items and is scored on a 5-point Likert type scale. A higher score indicates more fatigue. The Chinese version of the MFI-20 had a high internal consistency, with a Cronbach's alpha of 0.87[26].

Daytime sleepiness was quantified using the Epworth Sleepiness Scale (ESS), which consists of eight self-rated items with scores from 0 to 3 that measure a subject's habitual "possibility of dozing or falling sleep" in common situations of daily life. The total ESS score ranges from 0 to 24, with higher scores reflecting greater sleepiness and a score of 10 or greater indicating clinically significant daytime sleepiness [27]. A validated Chinese version of the ESS is available, which showed good high internal consistency (Cronbach's alpha = 0.83) [28].

The Short-Form 36 (SF-36) questionnaire is an internationally recognized universal scale for evaluating quality of life in neuro-oncology setting within the previous 4 weeks [29]. It mainly includes 36 statements, with 8 dimensions: physical function (PF), role physical (RP), body pain (BP), general health (GH), vitality (VT), social function (SF), role emotional problems (RE), and mental health (MH). SF-36 assesses two dimensions including physical composite score (PCS) and mental composite score (MCS). Total score on each SF-36 subscale ranges between 0 and 100. Greater score indicates better HRQoL [30]. Internal consistency of the Chinese version of the SF-36 subscale was acceptable, with Cronbach's alpha ranging from 0.72 to 0.88 for all subscales, except for the social functioning subscale (Cronbach's alpha = 0.39) and the vitality subscale (Cronbach's alpha = 0.66) [30].

The Pittsburgh Sleep Quality Index (*PSQI*) Questionnaire is the most commonly used retrospective self-report questionnaire for evaluating subjective sleep quality over a 1-month period. It consists of 19 questions grouped in seven components (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disorders, use of sleeping medications, and daytime dysfunction). Each answer provided a score ranges from 0 to 3 that are summed in a global *PSQI* score that ranges from 0 to 21. Higher scores indicate poorer subjective sleep quality. Sleep disturbance was defined as a *PSQI* score of >5[31]. The Chinese version of the *PSQI* revealed good internal consistency (Cronbach's alpha = 0.79) [32].

Statistical analysis

Descriptive statistics were provided depending on parametric distribution of measured variables. All continuous variables were tested for normality. The normal distribution was expressed by mean ($\pm$ standard deviation), and independent sample *t* test was used to assess group differences. The non-normal distribution was presented as median (25th and 75th percentiles), and Mann–Whitney *U* test was used to assess group differences. Categorical variables are described as number (percentage), and the chi-square test or Fisher exact test was used to assess group differences. The relations between sleep quality and all statistical variables in meningioma patients were examined with Pearson correlation analysis and/or Spearman rank correlation analysis. Binary stepwise logistic regression was performed on univariate variables with P value ≤ 0.10 to investigate the potential predictors of sleep disturbance in meningioma patients. The results were regarded as significant when $P < 0.05$ (two-sided). All analyses were performed using SPSS version 26.0.

Results

Patient characteristics

A total of 100 patients diagnosed with meningioma were investigated in the study. Meningioma patients'

Table 1 Demographic characteristics of meningioma patients ($N = 100$)

Characteristics	Overall (N=100)	PSQI>5 (N=43)	PSQI≤5 (N=57)	*P*
Age(years), Mean (SD, range)	59.20 (11.74, 25-88)	59.56 (11.13, 25-79)	58.93 (12.27, 28-88)	0.792
Gender, female, N (%)	72 (72)	31 (72.1)	41 (71.9)	0.986
BMI, kg/m^2, Mean (SD, range)	24.27 (3.47, 15.78-33.20)	23.73 (3.86, 15.78-32.05)	24.68 (3.12, 19.47-33.20)	0.175
Place of residence, N (%)				0.102
Urban	33 (33)	18 (41.9)	15 (26.3)	
Rural	67 (67)	25 (58.1)	42 (73.7)	
Marital status, N (%)				0.695
Married	93 (93)	41 (95.3)	52 (91.2)	
Other	7 (7)	2 (4.7)	5 (8.8)	
Education level, N (%)				0.481
≤ 9 years	83 (83)	37 (86)	46 (80.7)	
> 9 years	17 (17)	6 (14)	11 (19.3)	
Occupation, N (%)				0.974
Employed	56 (56)	24 (55.8)	32 (56.1)	
Unemployed	44 (44)	19 (44.2)	25 (43.9)	
Annual per capita income, RMB, N (%)				0.622
< 15,000	40 (40)	18 (41.9)	22 (38.6)	
15,000-33,000	27 (27)	13 (30.2)	14 (24.6)	
> 33,000	33 (33)	12 (27.9)	21 (36.8)	
Type of medical insurance, N (%)				0.830
Urban Residents Basic Health Insurance	6 (6)	3 (7.0)	3 (5.3)	
Employee medical insurance	29 (9)	14 (32.6)	15 (26.3)	
New Rural Cooperative Medical System	64 (64)	26 (60.5)	38 (66.7)	
Self-pay/Commercial insurance	1 (1)	0 (0)	1 (1.8)	
Tobacco use, yes, N (%)	22 (22)	9 (20.9)	13 (22.8)	0.823
Alcohol use, yes, N (%)	26 (26)	12 (27.9)	14 (24.6)	0.706
Menopausal status, yes, N (%)	58 (80.6)	26 (83.9)	32 (78)	0.537
Physical exercise, yes, N (%)	21 (24.7)	8 (21.6)	13 (27.1)	0.563

Data are presented as the means ± SD or the median (25th and 75th percentiles) for continuous variables, or the number (%) for categorical variables

P values were obtained with the chi-square test for categorical variables and independent samples *t* test or Mann–Whitney *U* test for continuous variables

Italicized values are those considered statistically significant

N number, *SD* standard deviation, *IQR* interquartile range, *BMI* body mass index

demographic, clinical, and psychological characteristics are summarized in Table 1 and Table 2. Results indicated that the mean age of meningioma patients was 59.20 (SD = 11.74, range = 25–88) years old, 72% of them were females. The median time since diagnosis of meningioma patients was 7 (IQR 7–30) days, and 55% patients had comorbidities. The majority of patients initially presented with intracranial hypertension (65%). The WHO grade at the time of resection was used to assign the WHO grade. The meningioma was WHO grade I for 76.3% of the patients, grade II for 22.7%, and anaplastic meningioma WHO grade III for 1% of the patients. The median tumor size was 3.6 (IQR 3–5) cm, and roughly half of the patients in our study had large tumors (2.5 cm ≤ diameter < 4.5 cm). The skull base meningioma accounted for 30%. The median KPS score of the meningioma patients was 90. According to NRS, the median headache score was 0.5 (range 0–8). Sixteen (16%) and 18 (18%) of the meningioma patients had anxiety and depression, respectively.

Self-reported sleep quality

Mean scores for each of the seven components by the *PSQI* are summarized in Table 3. The median *PSQI* global score was 5. We found that sleep disturbance was common among meningioma patients with 43% of the participants reporting poor sleep quality (score > 5) and 30% describing their sleep as fairly bad or very bad. The

Table 2 Clinical and psychological characteristics of meningioma patients ($N=100$)

Characteristics	Overall ($N=100$)	$PSQI>5$ ($N=43$)	$PSQI\leq5$ ($N=57$)	P
Time since diagnosis(days), median (IQR)	7 (7, 30)	10 (7, 30)	7 (5, 30)	*0.046*
Comorbidity, yes, *N* (%)	55 (55)	21 (48.8)	34 (59.6)	0.282
Hypertension	32 (32)	12 (27.9)	20 (35.1)	
Diabetes	11 (11)	4 (9.3)	7 (12.3)	
Initial presenting symptoms, *N* (%)				0.502
Intracranial hypertension	65 (65)	29 (67.4)	36 (63.2)	
Epilepsy	4 (4)	2 (4.7)	2 (3.5)	
Neurological deficits	24 (24)	11 (25.6)	13 (22.8)	
Others	7 (7)	1 (2.3)	6 (10.5)	
Maximal diameter (cm), median (IQR)	3.6 (3, 5)	4 (3, 5)	3.5 (2.6, 4.6)	0.184
Tumor size				0.096
Small (< 1 cm), *N*	0(0)	0 (0)	0 (0)	
Medium (1 cm ≤ diameter < 2.5 cm), *N* (%)	15 (15.2)	3 (7.1)	12 (21.1)	
Large (2.5 cm ≤ diameter < 4.5 cm), *N* (%)	48 (48.5)	20 (47.6)	28 (49.1)	
Giant (≥ 4.5 cm), *N* (%)	36 (36.4)	19 (45.2)	17 (29.8)	
Tumor lateralization, *N* (%)				0.229
Left	47 (47)	18 (41.9)	29 (50.9)	
Right	44 (44)	19 (44.2)	25 (43.9)	
Bilateral	9 (9)	6 (14.0)	3 (5.3)	
Tumor location, *N* (%)				0.657
Skull base	35 (35)	14 (32.6)	21(36.8)	
Non-skull base	65 (65)	29 (67.4)	36 (63.2)	
WHO grade, *N* (%)				0.089
Grade I	74 (76.3)	35 (83.3)	39 (70.9)	
Grade II	22 (22.7)	6 (14.3)	16 (29.1)	
Grade III	1 (1.0)	1 (2.4)	0 (0)	
Headache (NRS), median (IQR)	0.5 (0, 1)	1 (1, 2)	0 (0, 0)	*< 0.001*
KPS, median (IQR)	90 (90, 90)	90 (80, 90)	90 (90, 90)	*0.017*
Depression, yes, *N* (%)	18 (18)	12 (27.9)	6 (10.5)	*0.025*
Anxiety, yes, *N* (%)	16 (16)	12 (27.9)	4 (7.0)	*0.005*
Fatigue (MFI-20), median (IQR)	42 (36, 57)	50 (40, 69)	37 (36, 45)	*< 0.001*
ESS, median (IQR)	4 (2, 6)	3 (1.75, 6.25)	4 (2, 6)	0.477

Data are presented as the means ± SD or the median (25th and 75th percentiles) for continuous variables, or the number (%) for categorical variables

P values were obtained with the chi-square test for categorical variables and independent samples *t* test or Mann–Whitney *U* test for continuous variables

Italicized values are those considered statistically significant

WHO World Health Organization, *NRS* Numerical Rating Scale, *KPS* Karnofsky performance score, *MFI-20* Multidimensional Fatigue Inventory, *ESS* Epworth Sleepiness Scale

median nighttime sleep duration was 7 h, and 41% of the participant slept less than 7 h per night. It took a median of 15 min for them to fall asleep, and 18% of the patients reported sleep latency of 30 min or longer. Sleep efficiency lower than 85% was reported by 54% of the patients.

Differences in demographic, clinical, and psychological characteristics of meningioma patients between two groups

Comparison of meningioma patients with and without sleep disturbances is summarized in Table 1 and

Table 3 Self-reported sleep quality of meningioma patients (N=100)

Variables	Meningioma patients ($N=100$)
Subjective sleep quality, median (IQR)	1(0, 2)
Sleep latency, median (IQR)	1(0, 2)
Sleep duration, median (IQR)	1(0, 1)
Habitual sleep efficiency, median (IQR)	1(0, 2)
Sleep disorders, median (IQR)	1(1, 2)
Use of sleep medications, median (IQR)	0(0, 0)
Daytime dysfunction, median (IQR)	0(0, 0)
PSQI global, median (IQR)	5(2, 9)
nighttime sleep duration (h), median (IQR)	7(6.13, 8)
<7 h, N (%)	41(41)
Sleep latency (min), median (IQR)	15(10, 30)
>30 min, N (%)	18(18)
Sleep efficiency, median (IQR)	81.32(68.96, 93.21)
$<85\%$, N (%)	54(54)
Overall sleep quality	
Fairly bad or very bad, N (%)	30(30)
Sleep disturbance, yes, N (%)	43(43)

Data are presented as the median (25th and 75th percentiles) for continuous variables, or the number (%) for categorical variables

PSQI, Pittsburgh Sleep Quality Index; *IQR*, interquartile range

Table 2. Compared with meningioma patients without sleep disturbance, those with sleep disturbance showed longer time since diagnosis ($P=0.046$), lower KPS score ($P=0.017$), and more severe headache ($P<0.001$). Meanwhile, meningioma patients with sleep disturbance tended to have higher degree of anxiety ($P=0.005$), depression ($P=0.025$), and fatigue ($P<0.001$). However, no statistically significant associations were found with regard to comorbidities, initial presenting symptoms, tumor size, tumor lateralization, tumor location, and WHO grade of tumors. Also, differences between two groups with and without sleep disturbances regarding demographic characteristics were not statistically significant ($P>0.05$).

Correlations between demographic, clinical, psychological characteristics and sleep disturbance in meningioma patients

Taking sleep quality (the corresponding *PSQI* global score) as a continuous variable to explore correlations between demographic, clinical, psychological characteristics and sleep quality in meningioma patients. We found that headache (NRS) ($P<0.001$), anxiety ($P<0.001$), depression ($P=0.002$), and fatigue ($P<0.001$) were positively correlated with sleep disturbance, while KPS score ($P=0.021$) was negatively correlated with sleep disturbance (Table 4).

Statistically significant correlations between fatigue, severe headache, and sleep disturbance in meningioma patients

We used binary logistic regression analysis to investigate the significant correlates of sleep disturbance, as indicated in Table 5 . We found that fatigue (MFI-20) (OR = 1.042, $P=0.018$) and headache (NRS) (OR = 3.979, $P<0.001$) were significantly associated with sleep disturbance in meningioma patients.

Correlation between sleep quality and HRQoL in meningioma patients

As indicated in Table 6, there was a comparison of patients with and without sleep disturbance in terms of SF-36. Comparing the two groups, we found that the HRQoL of meningioma patients with sleep disturbance were significantly lower in the dimension score of PCS and MCS. After analyzing the differences in the eight dimensions of SF-36 scale between the two groups, we found that meningioma patients with sleep disturbance scored significantly lower than the control group in all domains of the SF-36 scale, except for the PF dimension.

Table 4 Correlations between demographic, clinical, psychological characteristics and sleep quality in meningioma patients ($N = 100$)

Characteristics	Sleep quality (PSQI global score)	
	r	*P*
Age	0.116	0.250
Gender	0.036	0.724
BMI	−0.222	0.066
Tobacco use	−0.015	0.884
Alcohol use	0.001	0.994
Menopausal status	0.147	0.219
Physical exercise	−0.020	0.859
Time since diagnosis	0.151	0.134
Comorbidity	−0.023	0.822
Tumor size	0.154	0.128
Tumor lateralization	0.125	0.217
Tumor location	0.052	0.606
WHO grade	−0.014	0.893
Headache (NRS)	0.654	*< 0.001*
KPS	−0.231	*0.021*
Depression	0.301	*0.002*
Anxiety	0.357	*< 0.001*
Fatigue (MFI-20)	0.479	*< 0.001*
ESS	−0.042	0.685

Italicized values are those considered statistically significant

Values are analyzed by Spearman correlation analysis

BMI body mass index, *WHO* World Health Organization, *KPS* Karnofsky performance score, *NRS* Numerical Rating Scale, *MFI-20* Multidimensional Fatigue Inventory, *ESS* Epworth Sleepiness Scale

Table 5 Analysis of binary logistic regression models in meningioma patients with sleep disturbance

	Beta	SE	*P*	Exp (B)	95% CI
Fatigue (MFI-20)	0.042	0.018	*0.018*	1.042	1.007, 1.079
Headache (NRS)	1.381	0.365	*<0.001*	3.979	1.947, 8.131

Italicized values are those considered statistically significant

MFI-20 Multidimensional Fatigue Inventory, *NRS* Numerical Rating Scale

Discussion

This is the first cross-sectional study to examine correlates of sleep disturbance in patients newly diagnosed with meningiomas prior to surgery and association with the quality of life. Sleep disturbance has been described in the literature as a frequent occurrence in patients with brain tumors[15, 33–35]. Our results are consistent with those findings, based upon *PSQI* score, 43% of the meningioma patients included in this study suffered from sleep disturbance. Fatigue and headache are significantly correlated with sleep disturbance in meningioma patients. In addition, meningioma patients with sleep disturbance have worse quality of life than meningioma patients without sleep disturbance.

Social demographic and clinical variables are closely related to sleep quality in patients with brain tumors. Pickering et al. [36] indicated that high BMI was associated with increased daytime sleepiness and daytime dysfunction by evaluating sleep quality, fatigue, and quality of life in 15 craniopharyngioma patients, in comparison to 15 healthy controls. Furthermore, they found that the degree of hypothalamic injury was significantly correlated to higher BMI. However, no obvious correlation was found between BMI and sleep disturbance in our study, which may be explained by the differences in the types or diagnosis and locations of brain tumors included, and the hypothalamic region may not be damaged by some tumors. Some studies explored whether brain tumor location, laterality, and size had a particular association with sleep disturbance [33, 37]. One study conducted in BT patients before surgery in Finland reported that poorer sleep was described by patients with anterior than posterior, but there was no difference in sleep between tumor size groups[37]. However, Mainio et al. [33] suggested that no statistically significant difference between brain tumor laterality groups was found in sleep quality before surgery. Our study failed to show any statistically significant correlation between sleep disturbance and size or site of tumor. These results could be attributed to the population heterogeneity and by the small size of the subgroups.

Only a limited number of studies have focused on the relationship between psychological symptoms and sleep quality in brain tumor patients [33, 38, 39]. The presence of psychological symptoms such as anxiety and depression is common in patients affected by primary brain tumors before surgery [40]. Furthermore, some of the existing literature argues that meningioma, over other types of tumors, can lead to greater levels of anxiety and depression, resulting in the aggravation of health-related complications [41]. In our study, patients with sleep disturbance had significantly higher levels of HADS-A and HADS-D scores compared with patients without sleep disturbance. The data indicated that it is necessary to systematically screen and manage patients with psychological symptoms, and the importance of targeted interventions to help meningioma patients get rid of sleep problems [39, 42].

Our study found that sleep disturbance correlated significantly with fatigue. This finding is in accordance with previous studies [39, 43, 44]. Fatigue is described as a subjective feeling of tiredness and a lack of vitality, and is a complexity of symptoms modulated by multiple associated factors. In neurological patients, fatigue can be a persisting

Table 6 Differences between quality of life in two groups grouped by sleep disturbance

All meningioma patients ($N=100$)		PSQI > 5 ($N=43$)	PSQI ≤ 5 ($N=57$)	P
SF-36				
PCS	80.75 (52.25, 92.44)	68.75 (35, 91)	86.75 (59.63, 94)	*0.003*
MCS	86.75 (62.34, 93.38)	78.13 (38, 90.75)	88.75 (78.42, 95.38)	*0.002*
PF	95 (75, 100)	85 (50, 100)	95 (82.50, 100)	0.163
RP	75 (0, 100)	50 (0, 100)	100 (25, 100)	*0.003*
BP	100 (62, 100)	84 (51, 100)	100 (74, 100)	*0.024*
GH	67 (45, 87)	60 (35, 82)	75 (51, 92)	*0.014*
VT	75 (60, 90)	70 (45, 80)	80 (70, 90)	*< 0.001*
SF	100 (75, 100)	87.50 (50, 100)	100 (100, 100)	*0.001*
RE	100 (55.67, 100)	100 (0, 100)	100 (100, 100)	*0.026*
MH	80 (64, 88)	72 (56, 84)	80 (72, 92)	*0.004*

Italicized values are those considered statistically significant

Values are presented as the median (25th and 75th percentiles) and analyzed by Mann–Whitney

SF-36 36-item short form health survey, *PCS* physical component summary, *MCS* mental component summary, *PF* physical functioning, *RP* role physical, *BP* bodily pain, *GH* general health, *VT* vitality, *SF* social functioning, *RE* role emotional, *MH* metal health

and/or recurrent symptom, which is not adequately alleviated by rest. Importantly, fatigue causes the greatest symptom distress and often occurs in symptom clusters with sleep disturbance, significantly lowering patients' quality of life, as reported by people with BT [15]. In our study, the risk for sleep disturbance was greater for patients with more severe fatigue, and logistic regression analysis showed a significant involvement of fatigue in sleep disturbance of meningioma patients. Although fatigue symptoms have a significant impact on patients' sleep quality, the diagnosis and treatment of fatigue symptoms are often insufficient. There is some evidence that patients experiencing fatigue may benefit from exercise interventions or psychological interventions to help patients manage fatigue symptoms [45, 46]. Health care providers should take active intervention to alleviate fatigue and improve sleep quality.

Moreover, we also found that headache and functional status (KPS score) were strongly correlated with sleep disturbance in correlation analysis, consistent with the literature [39, 47]. In addition, logistic regression analysis indicated that headache was independently associated with sleep disturbance, while functional status was not. Headache is the most frequent symptom and occurs in about two-thirds of meningioma patients [48]. Meningioma causes a headache may depend on compression of specific structures or an increase in intracranial pressure. Meningioma patients with headache may wake up frequently at night, making it difficult to fall asleep again. The relationship between sleep and headache seems to be bidirectional; in fact, headache may be a predictor of sleep disturbance and, in turn, sleep disturbance aggravates headache. Previous studies have shown that sleep disturbance may damage vital physiological processes, such as dopaminergic signal, opioid signal, and emotional regulation, which contribute to the development of hyperalgesia and maintenance of chronic pain [49]. Longitudinal data involving a larger sample are required to adequately understand the direction and magnitude of the relationship between sleep and headache. In addition, our study indicated that headaches based on NRS scores seemed to be relatively mild in this population regardless of sleep disturbance. This finding supported the hypothesis that meningiomas are less likely to cause headache because of their slow growth [50]. In our study, participants evaluated their average pain perception over the past week. In this period, headache may be relieved by taking painkillers, which may account for the mild headache in meningioma patients. One study exploring sleep disturbance among adults with primary or secondary malignant brain tumors indicated that KPS was a significant risk factors for sleep disturbance [39]. Our study found that meningioma patients with sleep disturbance had lower KPS score than meningioma patients without sleep disturbance. If sleep disturbance was present, these patients should be screened for functional impairment.

Considering the importance of quality of life in evaluating the prognosis of patients, this study also explored the impact of sleep disturbance on the quality of life of meningioma patients. Previous studies have found that meningioma patients had significantly lower quality of life than healthy controls before surgery [51, 52]. A recent systematic review highlights a picture emerging from studies reporting the results of HRQoL that sleep disturbance is a highly common and severe symptom in patients with brain tumors, leading to distress [15]. Furthermore, our study shows that meningioma patients with sleep disturbance score worse both in the domains of the PCS and MCS of SF-36, which indicated that the quality of life of these patients decreased

in many aspects, as it was previously reported. Nassiri et al. [18] have proved that sleep disturbance is highly correlated with the decline of quality of life. Interestingly, we also found that compared with meningioma patients without sleep disturbances, patients with sleep disturbances showed more serious anxiety, depression, and fatigue, which lower the quality of life.

To the best of our knowledge, this study is the first to explore the sleep quality and the association between sleep quality and quality of life of meningioma patients newly diagnosed and ready for surgery in China. However, several limitations of this study should be considered. First, this study did not provide the details of medication used in meningioma patients, such as corticosteroids and antiepileptics. Previous studies have shown that the use of corticosteroids and antiepileptics in BT patients may disrupt patients' sleep [43, 53]. Second, participants were recruited from a single neurosurgery clinic and sample size was rather small. Third, although the instruments used for this analysis have been validated in BT patients, self-report data are particularly subject to bias. Finally, because this study is a cross-sectional in design, we cannot exam the causal relationships between variables. Therefore, further longitudinal studies with objective or real-time sleep measures from multiple centers should be conducted to accurately quantify sleep quality, and develop the effective interventions to improve the sleep quality and the quality of life in meningioma patients.

Conclusion

In summary, this study provides valuable information on the aspects of sleep quality and quality of life in meningioma patients newly diagnosed and ready for surgery, revealing a high prevalence of sleep disturbance. In addition, our results indicated that fatigue and headache were significantly associated with sleep disturbance in meningioma patients, and the occurrence of sleep disturbance significantly diminishes the quality of life in meningioma patients physically and psychologically. Therefore, medical personnel should be aware of possible sleep disturbance in these patients and consider to refer them for sleep evaluation and take effective interventions to prevent or reduce sleep disturbance, so as to improve sleep quality of meningioma patients.

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Data availability All data generated or analyzed during this study are available upon reasonable request to the corresponding author.

Declarations

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of the Affiliated Hospital of Nantong University (No. 2020-K042).

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Not applicable.

Code availability Not applicable.

Conflict of interest The authors declare no conflict of interest.

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