Diagnosis of REM Sleep Behavior Disorder by Video-Polysomnographic Study: Is One Night Enough?

Jihui Zhang, MD[1]; Siu Ping Lam, MRCPsych[1]; Crover Kwok Wah Ho, RPSGT[1]; Albert Martin Li, MRCP, FHKAM (Paed)[2]; Joshua Tsoh, FHKAM (Psych)[1]; Vincent Mok, FRCP, FHKAM (Medicine)[3]; Yun Kwok Wing, FRCPsych, FHKAM (Psych)[1]

[1]Department of Psychiatry, [2]Department of Pediatrics, [3]Department of Medicine and Therapeutics, Faculty of Medicine, The Chinese University of Hong Kong, Shatin, Hong Kong, SAR

Study Objectives: Clinical features of RBD were typically episodic with limited data on the night-to-night reliability of the diagnostic video-PSGs. We aimed to assess on whether a single night study was adequate.

Design: Retrospective review

Setting: Sleep laboratory

Participants: 55 RBD patients with at least 2 consecutive video-PSGs.

Interventions: N/A

Methods: We analyzed 2 consecutive video-PSGs using REM-related EMG activity (REMREEA), REM sleep without atonia (RSWA), and video analysis of motor events.

Measurements and Results: A weak first night effect with increased REM sleep latency, increased stage 1 sleep, and increased arousal index were found. No differences were found in phasic and tonic EMG activity scores between night 1 and night 2. The presence of OSAS, use of CPAP, and clonazepam treatment did not affect the night-to-night variability and diagnostic accuracy. The kappas were 0.64, 0.51, and 0.31 between night 1 and night 2 for 10% REMREEA, RSWA, and video analysis respectively. Over 80% of patients could be diagnosed by various criteria in the first night, but the diagnostic ability could be enhanced to nearly 95% when combining PSG with video analysis. While both of the EMG criteria as well as the combination criteria had good reliability, video-analysis had poorer night-to-night reliability.

Conclusions: A single night of video-PSG was adequate in the diagnosis of RBD in most clinical patients and the combination of PSG and video analysis could enhance the detection rate further. Our findings have important resource implications.

Keywords: REM sleep behavior disorder; first night effect; night-to-night reliability; diagnostic agreement; PSG and video analysis.

Citation: Zhang J; Lam SP; Ho CKW; Li AM; Tsoh J; Mok V; Wing YK. Diagnosis of REM sleep behavior disorder by video-polysomnographic study: is one night enough? *SLEEP* 2008;31(8):1179-1185.

REM SLEEP BEHAVIOR DISORDER (RBD) IS A PARASOMNIA CHARACTERIZED BY ABNORMAL BEHAVIORS EMERGING DURING REM SLEEP WITH CONSEQUENT injury and sleep disruption.[1] Epidemiological study of RBD in both Hong Kong Chinese and Caucasian elderly population suggested a prevalence rate of 0.38% to 0.5%.[2,3] RBD is more frequently found in patients with synucleinopathy-related neurodegenerative diseases.[4-8] The rate of RBD in patients with neurodegenerative diseases ranged from 14.6% to almost 77% in different reports.[9]

The diagnosis of RBD may be missed if solely based on clinical history of sleep related injuries and there was only moderate interobserver reliability (κ= 0.46).[10] The hallmark polysomnographic (PSG) feature for RBD was the electromyographic (EMG) abnormalities during REM sleep.[11,12] A number of clinical series have documented abnormal tonic and/or phasic EMG activity during REM sleep in 92% to 100% of patients with RBD.[12-14] As a result, both presence of REM sleep without atonia (RSWA) and a history of injurious or disruptive behaviors during REM sleep are core criteria used to diagnose RBD in the second edition of the International Classification of Sleep Disorders (ICSD-2).[1] Nonetheless, there is no specific quantification of RSWA which might affect the validity and reliability of the diagnosis.

The clinical features of RBD and dream enactment behaviors are typically episodic and may not be observed during PSG monitoring.[15] In addition, the well-known first night effect (FNE) with decreased REM sleep duration and delayed REM sleep latency may affect the night-to-night variability of the PSG[16] and hence the diagnosis of RBD. Nevertheless, our research group found that a single night was sufficient to diagnose obstructive sleep apnea syndrome (OSAS) in children,[17] but in adults, a single night with negative PSG finding might miss the diagnosis of mild to moderate OSAS.[18] There was suggestion that a single night might not be enough for patients with suspected parasomnia,[19] but there was limited data on the night-to-night variability in RBD. Based on the scoring method in quantifying the phasic bursts and tonic EMG elevation during REM sleep as developed by Lapierre and Montplaisir,[20] Consens et al studied 23 subjects (with 7 probable and 2 possible RBD patients, 14 subjects without symptoms of RBD) for the night-to-night variability of PSG features in RBD.[21] In this study, few differences between night 1 and night 2 were found, and they suggested that the scoring method had good test-retest reliability.[21,22] However this study was limited by the relatively small sample size and the lack of concomitant analysis of video monitoring of detailed body movements. Other factors that might affect the results of this quantitative EMG scoring method such as the presence of OSAS were not examined. Therefore, we conducted this study

Disclosure Statement

This was not an industry supported study. Mr. Ho has participated in speaking engagements for Tyco Healthcare. Dr. Wing has received research support from Eli Lilly Asia, Inc. (Hong Kong). The other authors have indicated no financial conflicts of interest.

Submitted for publication February, 2008
Accepted for publication April, 2008

Address correspondence to: Dr. YK Wing, Professor, Director of Sleep Assessment Unit, Department of Psychiatry, The Chinese University of Hong Kong, Shatin Hospital, Shatin, Hong Kong SAR; Tel: 852-26367748; Fax: 852-26475321; E-mail: ykwing@cuhk.edu.hk

with a much larger sample to explore the night-to-night variability of both PSG and video features and to compare the various diagnostic criteria for identifying RBD.

METHODS

The present study was conducted with a retrospective design. Patients' clinical case notes and PSG reports were reviewed. Fifty-five patients with a confirmed diagnosis of RBD had undergone at least two consecutive nights of attended PSG with video recording in our sleep assessment unit. The basic recordings included standard electroencephalogram (C3-A2, C4-A1), electrooculogram (LE-A2, RE-A1), chin EMG, bilateral leg EMG (anterior tibialis muscles), bilateral arm EMG (extensor digitorum muscles), electrocardiogram, nasal-oral airflow, thoracic and abdominal respiratory efforts, oxyhemoglobin saturation, breathing sound, and body position. If CPAP was used, the CPAP pressure was also recorded. The sleep studies were closely observed by a technician for any movement or vocalization. Sleep stages were scored according to Rechtschaffen and Kales criteria, using 30-sec epochs, with modifications to allow the persistence of EMG tone during epochs that are otherwise clearly REM sleep (that is, epochs showing mixed–frequency, low-amplitude EEG waveforms with absence of sleep spindles or K complexes, accompanied by presence of rapid eye movements). REM sleep was terminated when sleep spindles or K complex or waking α rhythm appeared over the EEG channels or there was transition to slow wave sleep.[23] REM density was defined as the numbers of rapid eye movement per minute of REM sleep. Arousals were scored according to ASDA criteria.[24] Periodic leg movements (PLM) were defined as leg movements in one or both anterior tibialis muscles occurring in a series of 4 more such events, with inter-movement intervals of 5 to 90 sec. The PLM index (PLMI) was defined as the numbers of PLM per hour.[25]

The diagnostic criteria of RBD included: (1) history of problematic sleep behaviors that were harmful or potentially harmful, or disruptive of sleep continuity or disturbing to self and/or sleep partner; (2) PSG abnormality of excessive augmentation of chin EMG tone or excessive chin or limb EMG twitching during REM sleep; (3) identifiable motor activities related to dream enactment during REM sleep by video records (not related to PLMS or respiratory events).[1,26]

Quantitative Method of Scoring of EMG Activity and Video Analysis

The scorer for the PSG records was blind to the sequence of the night, except for those patients who were on CPAP in the second night. The EMG activity was scored by the following criteria:

Phasic EMG activity was scored from the submental EMG recording.[21] The phasic EMG events were defined as any burst of EMG activity lasting 0.1 to 5 sec with amplitude > 4 times the background EMG activity.[20] Short EMG bursts (< 100 msec) were not counted. The result was represented as the percentage of 3-sec mini-epochs with phasic EMG activity.

Tonic EMG activity: each 30-sec epoch was scored as tonic or atonic depending on whether tonic chin EMG activity was present for more or less than 50% of the epoch.

Increases of tonic or phasic EMG concurrent with respiratory events, PLMS, spontaneous arousals, and snoring signal artifacts were excluded from analysis.[11,20] The total EMG activity was presented as the percentage of REM related EMG activity (REMREEA) with the percentage of tonic EMG activity plus the percentage of phasic EMG activity rather than the average of the percentage of tonic EMG activity and phasic EMG activity.[21]

Video Monitoring

Based on videographic analysis, motor events were subdivided into following categories:

1. Significant movement was used to describe the apparent dream enactment in terms of complexity of behaviors, such as punching, sitting up, fighting, kicking, automatism, and jumping out of bed.
2. Vocalization included muttering, talking, laughing, and shouting.
3. Simple motor event was used to describe myoclonic events and muscle twitching that usually might not be observed or noticed by their bed partners but could be observed by the rater.
4. Other unclassified movement.
5. If the motor events were observed in the video during REM sleep, the patients would be marked as positive in related events. The total numbers of patients with any kind of motor events in night 1 and night 2 were analyzed.

Four Modified Criteria in Diagnosing RBD were Studied

1. 10% REM related EMG activity (10% REMREEA): The REM sleep time with tonic and phasic EMG activity were presented as a percentage of total REM sleep time. In this study, we used the 10% REMREEA as a cut-off point for indicating probable diagnosis of RBD.[21]
2. REM sleep without atonia (RSWA): The ICSD-2 criterion was defined as PSG abnormality of either excessive augmentation of chin EMG tone or excessive chin or limb EMG phasic twitching during REM sleep.[1,26] This clinical impression was based (in our sleep center) on consensus meeting by experienced polysomnographic technicians and clinicians. Basically, it differed from the 10% REMREEA criterion by lacking detailed quantification and could be considered as a crude measure of REM activities.
3. Video monitoring of REM related movement: Identifiable motor activities related to dream enactment during REM sleep by video analysis**.**
4. Combination criteria with both PSG and video: combination of PSG criteria REMREEA or RSWA with video motor events as the criteria of RBD.

Statistical Analysis

SPSS 13.0 (Release13.0; SPSS, Chicago, IL) for Windows was used for all statistical analysis. Descriptive statistics were given as means ± standard deviations as well as frequencies

(percentage). Paired-samples *t* test was employed to compare the normally distributed variables between night 1 and night 2 in 55 patients as well as the subgroup analysis. For those with non-normally distributed data in both overall group (n = 55) and subgroups analysis, Wilcoxon signed rank test was employed. Associations were tested for significance with the nonparametric Spearman correlation coefficient, while the κ coefficient and raw agreement were used to compare the night-to-night variability. Because of the extremes of the proportion of positive ratings, the kappas in some of the variables were very low even in those with high diagnostic agreement.[27] Therefore, we also used raw agreements to measure the agreements of various measurements between night 1 and night 2. All the *t*-tests and the nonparametric tests were 2-sided. P-value below 0.05 for most of the analysis and in view of multiple comparisons, adjusted P-value for the three subgroups comparison, $P < 0.017$, were considered statistically significant.

Table 1—Demographic Characteristics of 55 Patients with 2 Consecutive Nights PSG Study

Age (yr)	65.8 (11.2)
Male/female	44 (80%)/11 (20%)
Age of clinical history onset (yr)	61.4 (12.1)
Disease duration (yr)	4.4 (2.6)
Neurodegenerative diseases	9 (16.4%)
AHI in the first night	23.4 (24.9)
PLMS index in the first night	14.4 (27.6)
Treatment with antidepressants	8 (14.5%)
Treated with clonazepam when under study	18 (32.7%)
Dosage of clonazepam (mg)	0.51 (0.26)
With CPAP titration on the second night	28 (50.9%)
With both clonazepam and CPAP	11 (20%)
Without clonazepam and/or CPAP	19 (34.5%)

Data presented as mean (SD) or frequency (percentage)

RESULTS

As summarized in Table 1, our RBD patients were predominantly old male subjects with a mean duration of illness >4 years. Among them, 18 patients were already given low-dose clonazepam treatment for control of RBD symptoms, and 28 patients required CPAP titration for management of significant OSAS in the second night. Five patients with significant OSAS were on CPAP in the third night. The third night data of these 5 patients were not analyzed in the current study. Eight patients were treated with antidepressants for their psychiatric conditions: 4 with tricyclic antidepressants (clomipramine), 3 with SSRIs (2 with citalopram and 1 with fluoxetine), one with bupropion. Among the 9 patients with neurodegenerative diseases, 4 had Parkinson disease, 3 had dementia, and 2 had Parkinson disease and dementia.

Sleep Architecture Variability in Night 1 and Night 2

The results shown in tables 2 and 3 indicated that the major differences between night 1 and night 2 were mainly shortened REM sleep latencies, decreased stage 1 sleep percentages and decreased arousal index in night 2 when comparing with night 1. As for the subgroup differences, the first night effect (FNE)

Table 2—Sleep Architecture and EMG Variables of 55 Patients with RBD

	All subjects (n = 55)		
	Night 1	**Night 2**	**P value**
	Mean (SD)	**Mean (SD)**	
Time in bed (min)	507.43 (97.25)	516.94 (67.7)	0.41
Total sleep time (min)	354.89 (98.78)	358.73 (57.92)	0.73
Sleep efficiency (%)	69.75 (14.45)	69.58 (12.29)	0.94
Sleep onset latency[@] (min)	23.36 (16.53)	22.88 (15.42)	0.27
REM sleep latency[@] (min)	139.9 (91.25)	102.53 (72.76)	0.002*
Wake after sleep onset[@] (min)	132.88 (78.75)	138.94 (74.48)	0.37
Stage 1[@] %	18.49 (9.89)	14.58 (7.02)	0.013*
Stage 2%	61.19 (10.97)	63.58 (9.82)	0.08
Slow wave sleep[@] %	0.81 (1.72)	1.11 (2.99)	0.74
REM sleep[@] %	19.51 (8.01)	20.94 (7.60)	0.31
REM sleep duration[@] (min)	70.78 (37.61)	76.34 (32.73)	0.31
Arousal index[@]	20.39 (18.41)	12.41 (10.37)	0.002*
PLM index[@]	16.02 (28.41)	14.70 (22.59)	0.81
AHI[@]	24.13 (24.09)	10.11 (13.1)	<0.001*
% of tonic EMG activity[@]	24.31 (23.38)	26.55 (24.57)	0.47
% of phasic EMG activity[@]	9.36 (6.44)	9.55 (6.78)	0.80
% of phasic + tonic EMG activity[@]	33.67 (23.42)	36.10 (25.05)	0.43
REM density[@]	26.56 (12.02)	27.35 (13.90)	0.86

*P<0.05 [@] variables were tested by Wilcoxon signed-rank test. Other comparisons were tested by paired-samples *t* test
AHI: Apnea-hyponea index (28 subjects received CPAP on the second night with lower AHI)
PLM index: periodic limb movement index
REM density was defined as the number of rapid eye movements per minute of REM sleep.

Table 3—Sleep Architectures and EMG Variables in Subgroups

	Patients without CPAP or CNZ (n = 19)			Patients with CPAP titration on night 2 (n = 28)			Patients with CNZ (n = 18)		
	Night 1 Mean (SD)	Night 2 Mean (SD)	P value	Night 1 Mean (SD)	Night 2 Mean (SD)	P value	Night 1 Mean (SD)	Night 2 Mean (SD)	P value
Time in bed (min)	527.6 (101.3)	508.0 (72.6)	0.44	492.05 (100.72)	518.30 (69.03)	0.048	492.15 (82.64)	510.76 (55.70)	0.22
Total sleep time (min)	343.9 (98.6)	340.0 (61.8)	0.86	361.18 (105.00)	345.75 (70.79)	0.42	338.71 (97.46)	339.24 (80.87)	0.98
Sleep efficiency (%)	65.7 (15.3)	67.6 (12.9)	0.43	72.84 (12.76)	67.75 (14.15)	0.17	68.84 (15.90)	66.79 (16.40)	0.70
Sleep onset latency@ (min)	26.3 (18.5)	28.9 (20.6)	0.77	19.34 (14.60)	19.66 (11.68)	0.81	26.47 (15.35)	18.71 (7.55)	0.026
REM sleep latency@ (min)	144.3 (110.1)	102.5 (67.1)	0.23	140.41 (96.71)	100.52 (73.94)	0.011*	167.11 (88.53)	121.50 (94.16)	0.078
Wake after sleep onset@ (min)	154.7 (94.6)	136.1 (77.2)	0.33	100.52 (73.94)	112.44 (56.55)	0.015*	124.68 (78.53)	144.50 (81.32)	0.28
Stage 1, %@	15.6(9.5)	15.1 (7.9)	0.97	20.27 (10.30)	14.3 (6.87)	0.013*	18.53 (10.57)	12.74 (6.55)	0.062
Stage 2, %@	62.50 (12.6)	62.4 (12.4)	0.81	59.90 (10.12)	64.32 (8.92)	0.053	64.35 (9.76)	66.35 (9.76)	0.36
Slow wave sleep@ %	1.55 (2.32)	1.04 (2.33)	0.38	0.43 (1.23)	1.35 (3.67)	0.13	0.15 (0.47)	1.16 (3.82)	0.23
REM sleep@ %	20.38 (9.04)	21.45 (8.55)	0.55	19.4 (7.77)	20.43 (7.67)	0.68	16.99 (6.68)	19.98 (8.64)	0.19
REM sleep duration@ (min)	73.21 (45.76)	74.55 (33.06)	0.47	72.30 (33.57)	75.75 (34.49)	0.97	59.97 (28.73)	74.39 (39.99)	0.30
Arousal index@	15.39 (16.17)	14.82 (12.41)	0.79	25.81 (20.75)	11.21 (9.84)	0.001*	20.25 (18.00)	11.05 (11.20)	0.045
PLMS index@	13.82 (21.90)	13.73 (22.46)	0.86	13.76 (22.72)	15.02 (24.40)	0.81	26.78 (39.89)	20.89 (25.74)	0.60
AHI@	18.03 (19.89)	17.68 (18.84)	0.89	32.44 (26.61)	4.76 (6.12)	<0.001*	22.88 (26.40)	5.728 (7.44)#	0.003*
% of tonic EMG activity@	27.64 (26.10)	31.37 (25.56)	0.31	19.32 (20.70)	17.53 (18.02)	0.49	34.73 (21.60)	38.52 (24.4)	0.68
% of phasic EMG activity@	9.52 (5.79)	10.06 (5.81)	0.57	9.30 (7.31)	9.31 (7.71)	0.47	10.29 (8.10)	7.96 (4.15)	0.15
% of tonic + phasic activity@	37.16 (25.36)	41.43(24.70)	0.21	28.61 (21.87)	26.83 (21.19)	0.51	45.02 (18.67)	46.48 (22.72)	0.98
REM density@	23.53 (11.40)	24.84(16.79)	0.52	28.19 (12.83)	31.31 (11.15)	0.55	28.64 (15.85)	26.41 (13.11)	0.65

*Adjusted significant P value was < 0.017 (adjusted for multiple comparison).
@ variables were tested by Wilcoxon signed rank test. Other comparisons were tested by paired-samples *t* test
CNZ = clonazepam; #11 patients (61.1%) with CNZ treatment also received CPAP treatment.

Table 4—The Correlation Between Night 1 and Night 2 Among the Scores of Phasic and Tonic EMG Activity

	55 patients	Patients free from CPAP and clonazepam (n = 19)	Patients with CPAP on night 2 (n = 28)	Patients with Clonazepam (n = 18)
Tonic EMG activity	0.82*	0.82*	0.75*	0.668*
Phasic EMG activity	0.83*	0.90*	0.78*	0.713*

*P < 0.05

was mainly found in the patients with significant OSAS who required CPAP titration. With the adjusted P value < 0.017, most of the variables in patients group with CNZ and patients group without both CPAP and CNZ had no differences between night 1 and night 2, except for the AHI in patients group with CNZ. The AHI difference might reflect the CPAP titration of 11 patients. The average REM sleep durations in 55 patients were 70.8 min and 76.3 min respectively. About 7% (4/55) of the patients in the first night and 9% (5/55) in the second night had REM sleep duration < 20 min.

Quantitative EMG Activity Variability in Night 1 and Night 2

As CPAP and clonazepam treatment might affect sleep architecture and RBD clinical symptoms,[11,12,28] we compared the night 1 and night 2 variability in the overall group and the subgroups with clonazepam or CPAP treatment. The tonic and phasic EMG activity did not change from night 1 to night 2 in the overall group and among any subgroups. Similarly, REM density, another phenomenon thought to be related to the phasic activity in REM sleep did not differ between groups over the 2 nights.

Tonic EMG activity in night 1 was highly correlated with that recorded in night 2 ($r = 0.82$, $P < 0.05$), and similarly for phasic EMG activity ($r = 0.83$, $P < 0.05$) and total EMG activity scores (and $r = 0.78$, $P < 0.05$) (Table 4).

Diagnostic Agreements between Night 1 and Night 2 by Different Criteria (REMREEA, RSWA, video features, and combination criteria)

One patient's video record in the second night was missing in our database. EMG activity scoring method using 10% REMREEA and RSWA as well as video monitoring had satisfactory sensitivity in the diagnosis of RBD (ranging from 80% to 88.9%) in both nights (Table 5). Both the 10% REMREEA and RSWA had good night-to-night agreement, with κ ranging from 0.44 to 0.65, and raw agreements ranging from 0.86 to 0.93. However, the video features had poorer night-to-night reliability. In particular, "significant body movement," the most likely behavior that might lead to injury to patients and their bed partners, had low detection rates in both night 1 and night 2. Seven patients had <10% REMREEA on both nights (Table 5). Among them, 5 were on CPAP titration at the second night, and none were on CNZ treatment.

Both EMG criteria had good diagnostic agreement with each other but lower diagnostic agreements with video analy-

Table 5—Diagnostic Agreements of Various Diagnostic Measures and Criteria Between Night 1 and Night 2

	Night 1(+) and night 2 (+)	Night 1(-) and night 2 (+)	Night 1(+) and night 2(-)	Night 1(-) and night 2(-)	Detection rate on first night	Detection rate on second night	Kappa between night 1 and night 2	Raw agreement
Significant body movement (n = 54)	5	9	8	32	24.1%	25.9%	0.16	0.69
Vocalization (n = 54)	24	8	8	14	59.3%	59.3%	0.39	0.70
Simple motor event (n = 54)	18	6	7	23	46.3%	44.4%	0.52	0.76
Other movements not classified (n = 54)	26	8	8	12	63.0%	63.0%	0.37	0.70
Four modified diagnostic criteria								
1. Video analysis (n = 54)	42	6	3	3	83.3%	88.9%	0.31	0.83
2. 10% REMREEA (n = 55)	42	2	4	7	83.7%	80.0%	0.64	0.89
3. RSWA (n = 55)	45	3	3	4	87.3%	87.3%	0.51	0.89
4a. 10% REMREEA and video analysis (n = 54)	51	2	1	0	96.3%	98.1%	-	0.94
4b. RSWA and video analysis (n = 54)	50	3	1	0	94.4%	98.1%	-	0.93

10% REMREEA: 10% of EMG phasic and tonic activity in REM sleep
RSWA: REM sleep without atonia

Table 6—Diagnostic Agreements Between Night 1 and night 2 in Subgroups of Patients

	Patients without CPAP or CNZ (n = 19)		Patients with CPAP (n = 28)		Patients with CNZ (n = 18)	
	κ	Raw agreement	κ	Raw agreement	κ	Raw agreement
Significant body movement	0.55	0.79	–0.16	0.68	–0.31	0.53
Vocalization	0.27	0.68	0.28	0.64	0.38	0.71
Simple motor event	0.51	0.79	0.57	0.79	0.49	0.76
Other movements not classified	0.42	0.74	0.34	0.68	0.15	0.65
Four modified diagnostic criteria						
1. Video analysis	0.31	0.84	0.28	0.79	0.30	0.82
2. 10% REMREEA	0.44	0.90	0.65	0.86	-	1.0
3. RSWA	0.46	0.90	0.52	0.86	-	1.0
4a. 10% REMREEA and video analysis	-	0.95	-	0.93	-	1.0
4b. RSWA and video analysis	-	0.90	-	0.93	-	1.0

10% REMREEA: 10% of EMG phasic and tonic activity in REM sleep
RSWA: REM sleep without atonia

sis (Table 7). When combining EMG criteria (10% REMREEA or RSWA) with video features, the detection rates increased to 94.4% and 96.3% in first night (Table 5). Even when we further stratified different subgroup of patients (drug-free, on CPAP), the raw agreements between night 1 and night 2 for the combination criteria were found to be very high (ranging from 0.90 to 0.96) (Table 6). The results demonstrated that the combination criteria had both high sensitivities and good night-to-night reliability in detecting RBD.

DISCUSSION

The general demographic characteristics (with a mean age of 66.97 ± 9.82 years and male predominance of 82.3%) of the current study were comparable with existing literature and our own clinical series.[8,11,12,29] However, while awaiting PSG studies, 18 patients had already started low-dose clonazepam for their sleep problems. We did not stop the treatment prior to the PSG study in order to avoid potential REM rebound phenomenon. Nonetheless, clonazepam treatment seemed not to affect the PSG diagnosis of RBD.

Night-to-Night Variability of PSG Features and Video Analysis in RBD

The main characteristics of the FNE on sleep architectures in normal population included decreased total sleep time, lower sleep efficiency, less slow wave sleep and REM sleep, more frequent awakenings, and longer REM latency.[16] With regard to the accurate diagnosis of RBD, the amount of REM sleep duration was important in capturing the dream enactment behavior and REM sleep-related EMG abnormalities. In contrast to previous studies (in which some patients had little scorable REM sleep)[21,30] the average REM sleep duration of our patients was on average over 70 min in both nights, and less than 10% of the patients had REM sleep duration less than 20 min. In other words, it could be considered that there was adequate amount of REM sleep to unfold the abnormal EMG activity and motor events in our study. Interestingly, the typical features of first night effect, except for increased stage 1 sleep duration and prolonged REM sleep latency, were not conspicuous in this study. One might argue that CPAP titration in the second night might have posed another FNE for these patients with

Table 7—Diagnostic Agreements Between Different Criteria in Night 1 and Night 2

Diagnostic agreement between:	κ	Raw agreement
RSWA and 10% REMREEA criteria in night 1 (n = 55)	0.56	0.89
RSWA and 10% REMREEA criteria in night 2 (n = 55)	0.61	0.89
RSWA and video analysis in night 1 (n = 55)	0.27	0.82
RSWA and video analysis in night 2 (n = 54)	-	0.80
10% REMREEA criteria and video analysis in night 1 (n = 55)	-	0.75
10% REMREEA criteria and video analysis in night 2 (n = 54)	-	0.75

10% REMREEA: 10% of EMG phasic and tonic activity in REM sleep
RSWA: REM sleep without atonia

consequent variability in the diagnosis of RBD. Similarly, the use of clonazepam, a benzodiazepine, with known anxiolytic and therapeutic effects on RBD features, could potentially minimize FNE, behavioral presentations, and EMG activity.[20,31] However, FNE was not found in both the subgroup of patients with CNZ and the subgroup of patients without CNZ or CPAP. The scores of tonic and phasic EMG activities in the overall group, CPAP and clonazepam treatment groups did not differ between night 1 and night 2. In other words, high night-to-night reliability was found in both phasic and tonic EMG activity scores between night 1 and night 2 among all RBD patients and subgroups. The likely reason that clonazepam did not affect the diagnostic accuracy might be related to their low starting doses. Interestingly, no significant FNE was seen in the subgroup of RBD patients who were free from CPAP and clonazepam treatment, albeit there was a nonsignificant prolongation of REM sleep latency in the first night. Older subjects were suggested to have greater FNE.[18] It has been suggested that FNE might last for more than one night, and 3 consecutive nights might yield more reliable sleep data.[18,32] However, a recent study investigating the FNE phenomenon across 3 different periods of 4 consecutive nights suggested that the FNE was present only in the "very first night" of the first period.[33] Thus, our data of relatively weak FNE in this group of elderly patients with RBD argued against prominent adaptation problem for elderly, as well as the need for multiple sampling nights for RBD. Nonetheless, the relationship among age, sleep disorders, and FNE will require further study of larger sample size across different sleep disorders.

The EMG activity in current study seemed to be slightly lower than other studies, with EMG activity of 33.7% of REM sleep epochs in the first night and 36.1% in the second night.[5,11,20,21] The exact reasons were unclear but might be related to the exclusion of all EMG activity related to PLMS and respiratory events (as far as possible). In addition, most of the patients (>83%) in current study were thought to have "idiopathic" RBD, whereas most of the previous studies were conducted on those patients with advanced neurodegenerative diseases.[5,20,21]

The 10% REMREEA had good night-to-night reliability (κ = 0.64) and high sensitivity in identifying RBD in the current study. Similar findings were observed in the diagnostic criterion of RSWA. The rate of our patients with RSWA (87.3% in either night) is comparable with other RBD series,[12-14] which reported a rate of RSWA of 92% to 100%.

Video analysis is another important tool in the diagnosis of parasomnia. Frauscher et al. identified a high number and great variety of motor events during REM sleep (54 ± 23.2 events/10 min) in patients with severe RBD, compared to a control group (3.63 ± 2.3 events/10 min).[34] However, it was limited by small sample size (n = 5), and all visible movements regardless of type, amplitude, and duration were described as motor events. Our study had a much larger sample size with more detailed classification of motor events. Periodic leg movements were also found to be more frequent in RBD during REM sleep.[35] Thus, we excluded the motor events related to respiratory events, periodic limb movement events, and any kind of arousal-related movements as far as possible. In our study, the rates of individual subtypes of motor events ranged from 24.1% to 63% in the first night with high night-to-night variability (κ from 0.16 to 0.52 and raw agreements from 0.69 to 0.83). Overall, video analysis had only fair night-to-night reliability (κ = 0.31). In addition, only one-fifth of the patients presented with significant body movement in either night. It seemed that significant movements, the most likely behavior that might lead to injury to patients and others, did not occur frequently during monitoring and had high night-to-night variability. This was consistent with the clinical impression that the dream enactment behavior of RBD was episodic.

Comparison of Different Diagnostic Criteria

RSWA is proposed as one of the core criteria in diagnosing RBD by ICSD-2.[1] Although it seemed to have face validity, there was a need for further evidence to validate this criterion. In this regard, our study suggested that RSWA had similarly high detection rates (> 80%) in RBD and high diagnostic agreements (κ = 0.56 and 0.61, and raw agreements of 89.1%) with the objective quantification criterion of EMG abnormality (10% REMREEA) in both nights. In other words, the RSWA crude criterion has a good concurrent validity with the quantification criterion. Our study lends further support to the validity of RSWA and, hence, ICSD-2 criteria in diagnosing RBD.

The diagnostic agreements between PSG method and video analysis were only modest (with raw agreements ranged from 74.5% to 81.9%). However, when the PSG EMG criteria were augmented with video analysis, the diagnostic ability was further enhanced to over 94% (Table 5).

One of the major limitations of the study was the absence of a matched normal control group. However, as this study aimed at studying night-to-night variability, the inclusion of control subjects were felt not necessary. As the 10% REMREEA cutoff point was based on clinical impression with a small sample, among which all of the RBD patients had neurodegenerative diseases, future study should include a larger sample size with normal control and various severity of RBD to determine the diagnostic cutoff among different subtypes of RBD (such as typical RBD and drug-related RBD).[21] Another limitation of the

study was that the intrarater reliability for visual scoring procedure of quantitative EMG activity was not performed. The automated computerized algorithm developed by Consens and coworkers could greatly enhance test-retest reliability and efficiency and could be an important diagnostic tool for RBD.[22]

In summary, the 10% REMREEA, RSWA, and combination criteria (combining EMG and video features) had good night-to-night reliability and high sensitivity in identifying the diagnosis with clinical probable RBD. Although high sensitivity was also found in video analysis, its night-to-night reliability was poorer. In contrast to the suggestion that a single night study might not be adequate for patients with suspected parasomnia[19] and RBD,[22] we demonstrated that a single night of video-PSG study might be adequate clinically in diagnosing patients with a history suggestive of RBD, and the combination of PSG and video analysis could enhance the detection rate. In addition, the presence of OSAS and use of CPAP and clonazepam treatment did not influence the diagnostic accuracy of video-PSG. The cost implication of our study was significant, as an additional night of PSG will mean extra manpower, resources, and lengthening of the waiting list.[17]

REFERENCES

1. American Academy of Sleep Medicine (AASM). International classification of sleep disorders, 2nd edition: diagnostic and coding manual. Westchester, IL: American Academy of Sleep Medicine, 2005.
2. Chiu HF, Wing YK, Lam LC, et al. Sleep-related injury in the elderly--an epidemiological study in Hong Kong. Sleep 2000;23:513-7.
3. Ohayon MM, Caulet M, Priest RG. Violent behavior during sleep. J Clin Psychiatry 1997;58:369-76.
4. Comella CL, Nardine TM, Diederich NJ, Stebbins GT. Sleep-related violence, injury, and REM sleep behavior disorder in Parkinson's disease. Neurology 1998;51:526-9.
5. Gagnon JF, Bédard MA, Fantini ML, et al. REM sleep behavior disorder and REM sleep without atonia in Parkinson's disease. Neurology 2002;59:585-9.
6. Boeve BF, Silber MH, Ferman TJ, et al. REM sleep behavior disorder and degenerative dementia: an association likely reflecting Lewy body disease. Neurology 1998;51:363-70.
7. Plazzi G, Corsini R, Provini F, et al. REM sleep behavior disorders in multiple system atrophy. Neurology 1997;48:1094-7.
8. Arnulf I, Merino-Andreu M, Bloch F, et al. REM sleep behavior disorder and REM sleep without atonia in patients with progressive supranuclear palsy. Sleep 2005;28:349-54.
9. Thomas A, Bonanni L, Onofrj M. Symptomatic REM sleep behaviour disorder. Neurol Sci 2007;28 Suppl 1:S21-36.
10. Vignatelli L, Bisulli F, Zaniboni A, et al. Interobserver reliability of ICSD-R minimal diagnostic criteria for the parasomnias. J Neurol 2005;252:712-7.
11. Iranzo A, Santamaría J, Rye DB, et al. Characteristics of idiopathic REM sleep behavior disorder and that associated with MSA and PD. Neurology 2005;65:247-52.
12. Olson EJ, Boeve BF, Silber MH. Rapid eye movement sleep disorder: demographic, clinical and laboratory findings in 93 cases. Brain 2000;123:331-9.
13. Schenck CH, Hurwitz T, Mahowald MW. Symposium: normal and abnormal REM sleep regulation: REM sleep behaviour disorder: an update on a series of 96 patients and a review of the world literature. J Sleep Res 1993;2:224-31.
14. Sforza E, Krieger J, Petiau C. REM sleep behaviour disorder: clinical and physiopathological findings. Sleep Med Rev 1997;1:57-69.
15. De Cock VC, Vidailhet M, Leu S, et al. Restoration of normal motor control in Parkinson's disease during REM sleep. Brain 2007;130:450-6.
16. Suetsugi M, Mizuki Y, Yamamoto K, Uchida S, Watanabe Y. The effect of placebo administration on the first-night effect in healthy young volunteers. Prog Neuropsychopharmacol Biol Psychiatry 2007;31:839-47.
17. Li AM, Wing YK, Cheung A, et al. Is a 2-night polysomnographic study necessary in childhood sleep-related disordered breathing? Chest 2004;126:1467-72.
18. Le Bon O, Hoffmann G, Tecco J, et al. Mild to moderate sleep respiratory events: one negative night may not be enough. Chest 2000;118:353-9.
19. Malow BA. Paroxysmal events during sleep. J Clin Neurophysiol 2002;19:522-34.
20. Lapierre O, Montplaisir J. Polysomnographic features of REM sleep behavior disorder: development of a scoring method. Neurology 1992;42:1371-4.
21. Consens FB, Chervin RD, Koeppe RA, et al. Validation of a polysomnographic score for REM sleep behavior disorder. Sleep 2005;28:993-7.
22. Burns JW, Consens FB, Little RJ, Angell KJ, Gilman S, Chervin RD. EMG variance during polysomnography as an assessment for REM sleep behavior disorder. Sleep 2007;30:1171-8.
23. Rechtschaffen A, Kales A. A manual of standardized terminology, techniques and scoring system for sleep stages of human subjects. Los Angeles: Brain Information Service/ Brain Research Institute, UCLA, 1968.
24. American Sleep Disorders Association (ASDA). EEG arousals: scoring rules and examples: a preliminary report from the Sleep Disorders Atlas Task Force of the American Sleep Disorders Association. Sleep 1992;15:173-84.
25. American Sleep Disorders Association (ASDA): Recording and scoring leg movements. Atlas Task Force of the American Sleep Disorders Association. Sleep 1993;16:748-59.
26. American Sleep Disorders Association. International classification of sleep disorders. Rochester, MN: American Sleep Disorders Association, 1990.
27. Gordon G, Drummond R. Users' guides to the medical literature: a manual for evidence-based clinical practice. JAMA. 2001.
28. Iranzo A, Santamaría J. Severe obstructive sleep apnea/hypopnea mimicking REM sleep behavior disorder. Sleep 2005;28:203-6.
29. Wing YK, Lam SP, Li SX, et al. REM sleep behavioral disorder in Hong Kong Chinese – a clinical outcome study. (submitted)
30. Schenck CH. Clinical and research implications of a validated polysomnographic scoring method for REM sleep behavior disorder. Sleep 2005;28:917-9.
31. Riedel BW, Winfield CF, Lichstein KL. First night effect and reverse first night effect in older adults with primary insomnia: does anxiety play a role? Sleep Med 2001;2:125-33.
32. Toussaint M, Luthringer R, Schaltenbrand N, et al. Changes in EEG power density during sleep laboratory adaptation. Sleep 1997;20:1201-7.
33. Lorenzo JL, Barbanoj MJ. Variability of sleep parameters across multiple laboratory sessions in healthy young subjects: the "very first night effect". Psychophysiology 2002;39:409-13.
34. Frauscher B, Gschliesser V, Brandauer E, Ulmer H, Peralta CM, Müller J, et al. Video analysis of motor events in REM sleep behavior disorder. Mov Disord 2007;22:1464-70.
35. Wetter TC, Collado-Seidel V, Pollmächer T, Yassouridis A, Trenkwalder C. Sleep and periodic leg movement patterns in drug-free patients with Parkinson's disease and multiple system atrophy. Sleep 2000;23:361-7.