An Unusual Pattern of CPAP Usage

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A 31-year-old male sonar technician in the U.S. Navy was referred to us for ongoing continuous positive airway pressure (CPAP) management. He had been previously diagnosed with severe obstructive sleep apnea (apnea-hypopnea index [AHI] 97) and underwent tonsillectomy and nasal turbinate reduction. Although markedly improved following the procedure (AHI 18), snoring and symptoms recurred, prompting treatment with a CPAP device one year later. The patient's medical history was significant for hypertension which was controlled with an ACE inhibitor. He reported drinking 3-4 caffeinated beverages/week, rarely used alcohol, and was a lifelong non-smoker. Physical examination was notable for obesity (body mass index 36.6) and a Mallampati class 4 airway. At the time of his evaluation in our office, he reported using CPAP sporadically and scored 11/24 on the Epworth Sleepiness Scale. Review of his CPAP compliance report confirmed inconsistent usage with the exception of a conspicuous 3-month period. A sample of his CPAP usage report from this period is shown in **Figure 1**.

What is the explanation for the unusual pattern of CPAP usage?

Figure 1

Two representative 7-day tracings from the CPAP usage report of this patient. Green bars indicate days with cumulative CPAP usage exceeding 4 h, red bars indicate days with cumulative CPAP usage less than 4 h. The first number to the right of the graph indicates total time the patient is connected to the device; the second number is the total blower time.

Diagnosis: “6-on, 12-off” submarine shift work schedule.

Objective measurement of CPAP usage is widely available with current devices and has been mandated by the Center for Medicare and Medicaid Services (CMS). In addition to providing data relevant to the efficacy of treatment, CPAP usage reports may show sleep-wake patterns that are suggestive of chronically insufficient weeknight sleep, shift work, or circadian rhythm disorders.¹ For example, extended or “recovery” sleep on weekends and shifting of the major sleep period are easily recognized on the graphs of CPAP usage reports and provide opportunities to counsel patients regarding the effects of accumulated sleep debt as well as measures that promote better sleep and wakefulness in shift workers. Although military members may work and sleep in austere environments, CPAP can be successfully employed aboard ship. Compliance may even be encouraged by shipmates bothered by snoring, as was the case with this patient. This particular CPAP usage report shows an unusual pattern of shift work distinctive of U.S. Navy submarine watch schedules.

Submariners work and live in a unique, fully self-contained environment.² Nuclear power provides a nearly inexhaustible supply of energy that allows submerged operations for extended periods of time, essentially limited only by food supplies. A typical crew consists of approximately 120 men, most of who

are organized into 3 “watch” sections. Each watch section mans essential navigational and operational functions for 6 h and then turns over control to the next watch section. After watch relief, crew members are still required to participate in various formal training activities and drills during the next 6-h block, although time is also allotted for study, exercise, and recreation. Four meals are served daily. Finally, 6 h of relatively protected sleep time completes the daily cycle (**Figure 2**). “Berthing” or living quarters is streamlined and consist of no more than a simple mattress, reading light, electrical outlet, small storage space, and curtain for privacy. The “6-on, 12-off” watch schedule, which effectively results in an 18-h day, has been the standard in the U.S. submarine service for over 50 years and was developed in response to inherent space limitations that limit crew size while still providing around-the-clock manning.

Self-sustaining circadian rhythms are normally yoked to our solar day by regular exposure to sunlight and other environmental cues. Submarine crews live in an environment completely devoid of natural sunlight exposure and on an imposed 18-h sleep-wake cycle that lies outside the entrainment capacity of the human circadian pacemaker; hence circadian misalignment is inevitable. A study conducted during 6 consecutive weeks of submersion aboard the nuclear submarine USS Georgia revealed an average melatonin circadian period length of 24.35 ± 0.18 (mean $\pm$ SD) h in crew members scheduled to the 18-h day.³ This is slightly longer than the aver-

Figure 2

CPAP usage tracing from the patient next to a table that shows the shift work and sleep schedule employed by U.S. submarine crews. The “6-on/12-off” cycle results in a de facto 18-h day with a work and sleep cycle that repeats in 72-h blocks. This schedule allows the equivalent of 8 h sleep opportunity per 24-h day but requires a phase advance of 6 h between each sleep period. CPAP usage data in this case showed an average sleep duration of 5 h 3 min per imposed 18-h submarine day or an average sleep duration of 6 h 44 min extrapolated to the 24-h solar day.

age intrinsic circadian period reported from well-controlled forced desynchrony experiments of normal sighted individuals (24.1-24.2 h)⁴ and resulted in an accumulated phase delay averaging 13.5 h over the 6-week period. Although the “6-on/12-off” schedule allows the equivalent of 8 h sleep opportunity for every 24 h, the condensed day may also limit buildup of homeostatic drive which interacts with circadian rhythms of alertness to determine sleep propensity and length according to the 2-process model of sleep regulation.⁵ Actigraphy data obtained from 5 of the crew members in the study cited above showed an average sleep duration of 4 h 57 min sleep per 18-h day, or 6 h 36 min sleep extrapolated to our 24-h solar day. Our patient’s sleep duration, estimated from CPAP usage, was almost identical, i.e., 5 h 3 min/18-h day or 6 h 44 min extrapolated to our 24-h solar day.

Although the “6-on/12-off” schedule undoubtedly causes circadian misalignment, it remains the standard in the U.S. Navy submarine community. Attempts to maximize sleep opportunity and minimize daily sleep phase shifts using alternative schedules have thus far been unsuccessful. For example, a compressed work schedule that allowed for expanded time periods off duty for recovery sleep between the hours of 1800 and 0600 actually resulted in less sleep on average per 24 h and was rejected by crew members.⁶ Several features of submarine life may make rotating shift work, including the “6-on/12-off” schedule, tolerable to crew members. First, with this schedule only 3 watches or duty sections are required, limiting crew size and maximizing individual/personal space. Second, official duty or work periods are limited to a “relatively brief” 6-h stretch allowing more time for training as well as personal activities. Finally, in the enclosed environment of the submarine, commuting time is eliminated as are the confounding effects of poorly timed sunlight exposure and unpredictable scheduling changes that may interfere with adaptation to shift work.

PEARLS

1. CPAP can be successfully employed in austere environments including ships and submarines.

2. Objective monitoring of CPAP usage provides treatment documentation required by Medicare, and is useful in the clinical management of patients with obstructive sleep apnea.
3. Physicians are encouraged to personally examine CPAP usage graphs in order to assess sleep-wake patterns and not rely solely on summary data provided by DME providers.
4. Shift work can take unusual forms including the “6-on/12-off” cycle typically employed by U.S. submarine crews.

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