FLIGHT SAFETY FOUNDATION
HUMAN FACTORS & AVIATION MEDICINE
Vol. 51 No. 1 *For Everyone Concerned With the Safety of Flight* January–February 2004

Proper Treatment Minimizes Risks of Obstructive Sleep Apnea

Without treatment, the repeated awakenings caused by obstructive sleep apnea (OSA) can result not only in daytime sleepiness but also in depression, irritability and memory problems. OSA also may increase the risk of heart attack and stroke.

Stanley R. Mohler, M.D.

Sleepiness and fatigue — cited by pilots as factors in operational errors[1] — result from inadequate sleep quality and inadequate sleep duration. For many people, inadequate sleep is a result of snoring, which can cause multiple awakenings during each sleep period and can prevent them from achieving adequate intervals of restful sleep. In some cases, these awakenings are a result of obstructive sleep apnea (OSA),[2] which causes a person to repeatedly stop breathing for 10 seconds or more — long enough to decrease the amount of oxygen and increase the amount of carbon dioxide in the blood and the brain.

Many people — including pilots and other crewmembers — are unaware that they have OSA, which often is not identified during a routine physical examination. Nevertheless, once identified, OSA can be treated successfully.

Claus Curdt-Christiansen, M.D., chief of the Aviation Medicine Section of the International Civil Aviation Organization (ICAO), said that its symptoms make severe OSA "incompatible with flying as a pilot."

"Somnolence during the day, constant fatigue, severe cognitive impairment, etc., are all dangerous in the cockpit," he said. "Any pilot suspected of OSA should be grounded and should undergo a full investigation, including a night in a sleep laboratory. If treatment is successful … a return to flying should be possible."[3]

In every 24-hour period, people require an average of seven hours to eight hours of quality sleep. Throughout the sleep period, there are different stages of sleep, which are best experienced when sleep is uninterrupted. The sleep period follows a predictable pattern, which includes the following stages:[4]

- Stage 1 sleep is light sleep from which an individual can be awakened easily. Muscle activity slows; many people experience sudden muscle contractions, which often are

preceded by the sensation that they are beginning to fall. Eyes move slowly. For most people, Stage 1 sleep accounts for no more than 5 percent of sleep[5]; people with sleep disorders such as OSA, however, may spend significantly more time in Stage 1 sleep;

- Stage 2 sleep involves a slowing of brain waves (fluctuations of electrical activity measured by electrodes), a decrease in body temperature and a cessation of eye movement;

- During Stage 3 sleep, very slow brain waves (delta waves) begin to appear among smaller, faster brain waves;

- During Stage 4 sleep, these very slow brain waves become more predominant. There is no movement of the eyes or muscles. Stage 4 sleep, together with stage 3 sleep, is known as "deep sleep" from which it is very difficult to wake someone; a person who is awakened does not adjust immediately to being awake and may feel groggy and disoriented for several minutes; and,

- During rapid eye movement (REM) sleep, brain waves again become faster; the breathing rate increases, and breaths become irregular and shallow; the heart rate increases; and blood pressure increases. Muscles in the arms and legs are temporarily paralyzed, and the eyes move rapidly in different directions (usually from side to side). Dreams occur during REM sleep.

During each normal sleep period, people typically experience all five phases of sleep in order, from Stage 1 sleep through REM sleep, and then the cycle begins again. A complete sleep cycle requires about 90 minutes to 110 minutes. The earliest sleep cycles in each sleep period involve relatively little REM sleep and more deep sleep; as the sleep period progresses, time in REM sleep increases and time in deep sleep decreases. For adults, about 50 percent of each sleep period is in Stage 2 sleep, and about 20 percent is in REM sleep; the remaining 30 percent is divided among Stage 1 sleep, Stage 3 sleep and Stage 4 sleep.

OSA Occurs Most Often Among Men Between 40 and 65

Sleep specialists have diagnosed more than 70 sleep disorders; OSA is one of the most common. Researchers have estimated that about 1 percent of men and 0.5 percent of women — including 4 percent of men older than age 50 and 2 percent of women in the same age group — have OSA; men between the ages of 40 and 65 are considered most likely to develop the disorder. The U.S. National Institutes of Health (NIH) says that in the United States alone, 18 million people have OSA.[6,7]

The disorder is most likely to occur among people who snore loudly — although most people who snore do not have OSA — and those who also are overweight, have high blood pressure (hypertension) or have a physical abnormality involving the nose, throat or another part of the upper airway. Sleep apnea may be genetic. Use of alcoholic beverages and/or sleeping pills may exacerbate the problem.

Snoring occurs when there is a disruption of the free flow of air through the upper airway — the passages at the back of the nose and mouth — and, as a result, the tongue, soft palate (the roof of the mouth at the back of the throat), upper throat and uvula (the fleshy tissue that hangs from the back of the throat) touch each other and vibrate during breathing. OSA results from the repetitive partial collapse or complete collapse of the upper airway during inhalation. The collapse often is a result of anatomical problems or medical problems involving the upper airway. For example, in some people, OSA occurs because the throat muscles and the tongue relax and partially block the airway's opening; in other people, the airway is blocked when the muscles at the base of the tongue and the uvula relax and sag; and in others who are obese, extra tissue narrows the space along which air may pass (Figure 1).

For someone with OSA, breathing may stop 30 times an hour or more — nearly 250 times during a typical eight-hour sleep period — for as long as one minute each time. When one of

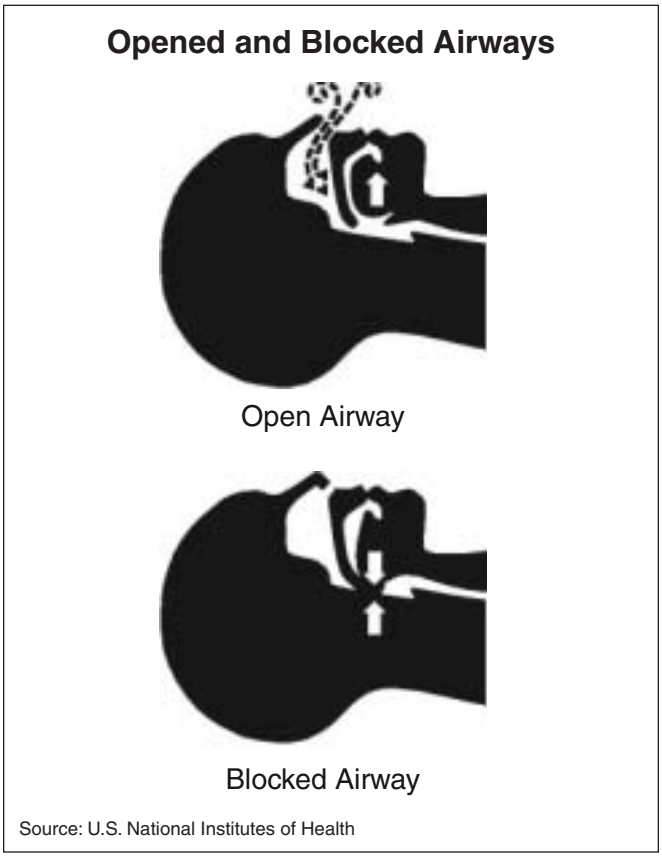

Figure 1

these episodes occurs, the person cannot breathe in atmospheric oxygen and exhale carbon dioxide; as a result, oxygen levels in the blood decrease and carbon dioxide levels increase. This imbalance causes the brain to awaken the person, who gasps to take in air, falls back to sleep and resumes snoring until the next episode.

Because the episodes are so frequent, people with OSA cannot experience deep sleep. As a result, regardless of how long their sleep period is, they feel sleepy the next day.

In addition to sleepiness, OSA also may result in depression, irritability, sexual dysfunction and memory difficulty. About 50 percent of people with OSA also have high blood pressure, and researchers believe that OSA is a cause of high blood pressure. OSA also may increase the risk of heart attack and stroke.[8]

Snoring Complaints Often Precede OSA Diagnosis

OSA often is diagnosed after someone who shares the individual's sleeping area hears his or her loud snoring and observes the apparent struggle for breath. The individual — or friends or coworkers — may observe that he or she falls asleep during the day, often while talking, working or driving a car.

For example, the U.S. National Transportation Safety Board (NTSB) cited OSA as a factor associated with a Feb. 21, 2000, accident at Chicago (Illinois, U.S.) O'Hare International Airport in which a refueling truck struck an American Airlines Fokker F28 Mk 100 that was parked at a gate. One person received serious injuries, six people received minor injuries, and 46 people were not injured.[9]

The NTSB said, in its final report, that the probable cause of the accident was that "the driver of the refueling truck fell asleep, which resulted in [his] not maintaining clearance with the parked aircraft."

An airline ground service manager said that the driver told him that "he remembered starting to pull in front of the wing, and then becoming aware that he was in the truck cab and was against the aircraft. He said he really did not remember how he got out of the truck. I asked him if he had been having any trouble staying awake earlier in the day. He told me that he felt fine and … that he had apparently just 'blacked out.'"

A medical evaluation and sleep-study evaluation of the truck driver showed that he had severe OSA and hypersomnolence (excessive sleepiness). The same driver had been involved in another accident on Oct. 30, 1999, in which the refueling truck that he was driving struck two other refueling trucks in a parking lot. The report said that the driver had said that he was "going to back into a parking spot when he dozed off and was awakened by the impact."

Physicians may use one or more diagnostic tests to determine whether someone has OSA, including the following:

- Polysomnography, which records a number of body functions during sleep, often is conducted overnight in a sleep laboratory, where a patient's sleep is monitored by an electroencephalographic recorder to evaluate brain waves, an electrocardiogram to record the heart rate, and other equipment to evaluate the respiratory rate, the movement of the muscles in the jaw, the airflow from the nose and mouth, leg movements, eye movements and the level of oxygen in the blood. Snoring episodes are quantified, and the longest period of cessation of breathing is recorded; during this period, measurements are taken of the level of oxygen in the blood. After the night ends, the sleep data are evaluated to determine how much the patient slept, how efficient his or her sleep was and what type of OSA treatment is required; and,

- The multiple sleep latency test evaluates how quickly someone falls asleep by giving the test subjects several opportunities to fall sleep at times when they normally would be awake. People without sleep disorders usually fall asleep within 10 minutes to 20 minutes; those who fall asleep in less than five minutes probably have a sleep disorder that requires treatment.

OSA can be classified according to a respiratory distress index (RDI) developed by the American Sleep Disorder Association; this index often is developed during polysomnography. OSA that consists of zero episodes to five episodes of sleep apnea per hour is classified as normal. OSA involving from five episodes to 20 episodes per hour is classified as mild. OSA involving from 20 episodes to 40 episodes per hour is classified as moderate, and OSA with more than 40 episodes per hour is classified as severe.

Treatments Include Weight Loss, Surgery, Airway Devices

For some people with mild OSA, behavioral changes may be the only treatment required. Those changes may include avoiding use of alcoholic beverages, tobacco and sleeping pills, each of which may adversely effect the portion of the brain that regulates sleep, making the airway more likely to collapse and prolonging individual episodes of OSA. For people who are overweight, weight loss may reduce the number of episodes of OSA. People who experience OSA only when sleeping on their backs may benefit from the use of pillows or other devices to prop them on their sides.

People with moderate or severe OSA typically require other treatment in addition to behavioral changes.

Medications usually are not effective against OSA, and the most common treatment is the use of continuous positive airway

The most common treatment for obstructive sleep apnea is use of a continuous positive airway pressure (CPAP) device like the one this man is using. Air from the device is forced through the nasal passages at a pressure high enough to prevent interruptions in his breathing. Source: Respironics

pressure (CPAP), in which a sleeping patient wears a mask over the nose; a tube connects the mask to an air blower that forces air through the nasal passages at a pressure high enough to prevent any interruption in breathing.[10]

A newspaper reporter described his first experience with a CPAP device this way: "It takes some getting used to, but after a few minutes, the rush of air ceases to be tangible. You don't notice the wind, and eventually, you fall asleep. The first night, my mask wasn't on tight enough, so I woke up a couple of times to adjust it."[11]

The reporter said that the air pressure in his CPAP device was adjusted to eight centimeters; 12 centimeters is the average setting for someone with OSA.

"I was surprised at the pressure that blows out of the hose, even at a setting of eight centimeters: hard enough to part your hair or to huff a wad of paper off a nightstand," he said.

An airline transport pilot was diagnosed with OSA during a routine aviation physical examination when — after all tests had been completed and the results were considered normal — he told the physician that he almost always felt tired and that he had fallen asleep while talking to a superior. The pilot was grounded for a variety of tests, including one test that revealed severe OSA. Three months later, after the pilot lost 20 kilograms (44 pounds), tests revealed a 65 percent reduction in the number of OSA episodes during a single sleep period. The pilot then began CPAP treatment, and tests showed that his sleep pattern had returned to normal and his OSA was under control.[12]

The pilot received a waiver for a Class 1 medical certificate with the conditions that he use the CPAP device during sleeping hours and that he undergo regular polysomnography.

The Sleep Apnoea Trust, with headquarters in the United Kingdom, recommends that anyone who carries a CPAP device on an airplane — including pilots and other crewmembers — also should carry an explanatory letter from a sleep clinic or physician to show to customs officials or airport security officials, if necessary. The organization also recommends that anyone taking a CPAP device to another country check the "electrical details" to ensure that the device will function using the voltage that will be available.[13]

Another treatment method involves the use of a dental appliance to reposition the lower jaw, tongue, soft palate and uvula; stabilize the lower jaw and tongue; and/or improve muscle tone

in the tongue. There are about 40 types of appliances, which resemble orthodontic retainers or sports mouth guards. The appliances, which are worn inside the mouth, are designed to correct mild OSA and/or snoring. The appliances are available from specialists in dental sleep medicine.[14]

Side effects may include damage to teeth, soft tissues in the mouth and the jaw joint.[15]

Several types of surgery are performed to alleviate OSA and/or snoring, including the following:

- Tonsils, adenoids, nasal polyps or other growths or tissues that obstruct the airway may be removed;

- Structural deformities, such as a deviated septum (a bend in the cartilage or bone separating the nostrils that results in an obstruction to the flow of air through one nostril), may be corrected to increase the size of the airway;

- Uvulopalatopharyngoplasty (UPPP), or removal of excess tissue at the back of the throat is the most commonly performed surgery for OSA. The procedure is successful in about 30 percent of cases;[16]

- Tracheostomy, which is performed only on people who have especially severe forms of OSA, involves creation of a small hole in the windpipe through which a tube is inserted. The tube is closed during waking hours so that the person can speak and can breathe normally, but the tube is opened during sleep to allow air to flow directly to the lungs. The National Heart, Lung and Blood Institute (NHLBI) at NIH described the procedure as highly effective but also as an "extreme measure that is poorly tolerated by patients and rarely used"; and,

- A number of other procedures, including reconstruction of the lower jaw (if jaw deformities are the cause of OSA) and surgical treatment of obesity.

Other procedures are used to treat snoring — but generally not to treat OSA. Among these procedures are the following:

- Laser-assisted uvulopalatoplasty (LAUP) sometimes is performed to eliminate snoring but has not been proved an effective treatment against OSA.[17] A laser is used to eliminate excess tissue in the back of the throat. The NHLBI said, "Elimination of snoring, the primary symptom of sleep apnea, without influencing the condition may carry the risk of delaying the diagnosis and possible treatment of sleep apnea in patients who elect LAUP." Radiofrequency ablation is a similar procedure, in which a needle electrode is used instead of a laser;[18]

- Injection snoreplasty, in which Sotredecol, a medication typically used in treating varicose veins, is injected into the soft palate to stiffen the tissue and reduce or eliminate snoring;[19]

- Nasal strips, which are placed on the nose to lift the sides of the nose and open nasal passages, are designed to improve breathing and to reduce or eliminate snoring — if the snoring results from an inability to breathe normally through the nose. Manufacturers say that someone who believes that his or her snoring is a symptom of OSA should consult a physician; and,[20]

- Anti-snoring throat sprays are designed to lubricate the throat and to firm loose throat tissues.

OSA can be a debilitating and potentially life-threatening disorder. Nevertheless, with proper treatment, pilots who have OSA can correct their disrupted sleep patterns, reduce their fatigue and retain their medical certification.♦

Notes

1. Mohler, Stanley R. "Pilot Fatigue Manageable, But Remains Insidious Threat." *Human Factors & Aviation Medicine* Volume 45 (January–February 1998).

2. Another, less common, type of sleep apnea is central sleep apnea, which is caused by a dysfunction in the lower brain stem — the part of the brain that controls breathing. This type of sleep apnea usually occurs among people with a disease such as encephalitis or a stroke that has damaged the lower brain stem.

3. Curdt-Christiansen, Claus. E-mail communication with Werfelman, Linda. Alexandria, Virginia, U.S., Jan. 9, 2004. Flight Safety Foundation, Alexandria, Virginia, U.S.

4. U.S. National Institutes of Health (NIH) National Institute of Neurological Disorders and Stroke (NINDS). *Sleep: A Dynamic Activity.* <www.ninds.nih.gov/health_and_medical/pubs/understanding_sleep_brain_basic_.htm>. Jan. 9, 2004.

5. Sleep Disorders Center of Central Texas. *The Stages of Sleep.* <www.sleepdoctor.com/stages.htm>. Jan. 9, 2004.

6. Brietzke, Scott E.; Mair, Eric A. "Injection Snoreplasty: How to Treat Snoring Without All the Pain and Expense." *Archives of Otolaryngology — Head and Neck Surgery* Volume 124 (May 2001): 503-10.

7. NINDS.

8. NIH National Heart, Lung and Blood Institute (NHLBI). *Facts About Sleep Apnea,* NIH Publication no. 95-3798. September 1995.

9. U.S. National Transportation Safety Board. Accident report CHI00LA076. Feb. 21, 2000.

10. Manufacturers of continuous positive airway pressure (CPAP) devices include the following, in alphabetical order:

    - AirSep, 401 Creekside Drive, Buffalo, NY 14228-2085 U.S. Telephone: (888) 874-0202 (U.S.) or +1 (716) 691-0202. Internet site: <www.airsep.com>

- DeVilbiss (Sunrise Medical), 100 DeVilbiss Drive, Somerset, PA 15501-2125, U.S. Telephone: (800) 338-1988 (U.S.) or +1 814 443-4881. Internet site: <www.sunrisemedical.com>

- Fisher & Paykel Healthcare, 15 Maurice Paykel Place, East Tamaki, Auckland, New Zealand. Telephone: +64 9 574 0100. Internet site: <www.fphcare.com>

- ResMed, 14040 Danielson St., Poway, CA 92064-6857, U.S. Telephone: (800) 424-0737 (U.S.) or +1 (858) 746-2400. Internet site: <www.resmed.com>

- Respironics, 1010 Murry Ridge Lane, Murrysville, PA 15668-8525 U.S. Telephone: (800) 345-6443 (U.S.) or +1 (724) 387-5200. Internet site: <www.respironics.com>

11. McClain, Buzz. "Behind the Mask: Air Flow Devices May Look Funny, But They Get Apnea Patients Safely Through the Night." *The Washington Post*. Dec. 2, 2003, Page 1F.

12. Panton, S.; Norup, P.W.; Videbaek, R. "Case Report: Obstructive Sleep Apnea — An Air Safety Risk." *Aviation, Space and Environmental Medicine* Volume 68 (December 1997): 1139–1143.

13. The Sleep Apnoea Trust. *FAQ*. <www.sleep-apnoea-trust.org>. Jan. 14, 2004.

14. Academy of Dental Sleep Medicine. *Snoring and Sleep Apnea.* <www.dentalsleepmed.org/general.htm>. Jan. 13, 2004.

15. NHLBI.

16. Wooten, Virgil D. "Sleep Disorders in Pilots." *The Federal Air Surgeon's Medical Bulletin.* Spring 2002.

17. NHLBI.

18. American Academy of Otolaryngology — Head and Neck Surgery. *Snoring: Not Funny, Not Hopeless.* <www.entnet.org/healthinfo/snoring/snoring.cfm>. Jan. 13, 2004.

19. Brietzke and Mair.

20. CNS. *Breathe Right: Answers to the Most Frequently Asked Questions.* <www.breatheright.com/faq/faq.asp>. Jan. 13, 2004.

About the Author

Stanley R. Mohler, M.D., is a professor of aerospace medicine and vice chairman of the Department of Community Health at Wright State University School of Medicine in Dayton, Ohio, U.S.

Mohler, who holds an airline transport pilot certificate and a certified flight instructor rating, was director of the U.S. Federal Aviation Agency's Civil Aviation Medicine Research Institute (now the U.S. Federal Aviation Administration's Civil Aerospace Medical Institute) for five years and chief of the Aeromedical Applications Division in Washington, D.C., U.S., for 13 years.

Mohler received the 1998 Flight Safety Foundation Cecil A. Brownlow Publication Award for journalism that enhances aviation safety awareness.

Human Factors & Aviation Medicine

Staff: Roger Rozelle, director of publications; Mark Lacagnina, senior editor; Wayne Rosenkrans, senior editor; Linda Werfelman, senior editor; Rick Darby, associate editor; Karen K. Ehrlich, web and print production coordinator; Ann L. Mullikin, production designer; Susan D. Reed, production specialist; and Patricia Setze, librarian, Jerry Lederer Aviation Safety Library

Subscriptions: One year subscription for six issues includes postage and handling: US$240. Include old and new addresses when requesting address change. • Attention: Ahlam Wahdan, membership services coordinator, Flight Safety Foundation, Suite 300, 601 Madison Street, Alexandria, VA 22314 U.S. • Telephone: +1 (703) 739-6700 • Fax: +1 (703) 739-6708