neic bulldogs. In addition, some fibrosis, muscle fiber necrosis, and inflammation were seen in the sternoglossal muscles of the apneic dogs. As referenced by Teculescu and Vespignani, Smirne et al. examined medium pharyngeal constrictor muscle tissue removed from four patients with laryngeal carcinoma who had a history of heavy snoring compared with tissue removed from nine nonsnorers. There are some problems with this study. No subjects had the presence or absence of snoring or the presence or absence of OSA verified by objective means. The snorers were significantly older than the nonsnorers, and although the subjects in general were not obese, a weight comparison between the groups was not provided. Constrictor instead of dilator muscles were studied. In spite of these design limitations, the results of this study are of interest. It was found that the medium pharyngeal constrictor muscle of snorers had a greater proportion of type 2a fibers and a lower proportion of type 1 and 2b fibers than the same muscle taken from nonsnorers. As these investigators discuss, obesity also is associated with a decrease in the fatigue-resistant type 1 fibers in muscles. Whether or not these changes are constitutional or secondary, the outcome of these changes might be to make obese individuals more susceptible to upper airway collapse in the face of increased pleural pressure necessary to overcome the decreased compliance of the obese, heavy chest wall. Type 2a fibers, however, are somewhat fatigue-resistant so that the end results of these changes is uncertain, unless tested physiologically.

Recently, information has been generated about the functional properties of normal upper airway muscles. The van Lunteren et al. article has shown that contraction characteristics, fiber type, and fatigue susceptibility of animal pharyngeal muscles differ among the upper airway muscles themselves and also differ from the characteristics of the diaphragm and limb muscles. Pharyngeal muscles were found to have faster contraction times than the diaphragm. This property allows contraction of the upper airway inspiratory muscles to begin and peak before the diaphragm so that the upper airway is stabilized before the inspiratory intraluminal subatmospheric pressure is generated by the chest wall inspiratory muscles. Salome and van Lunteren found that fatigue was produced in the genioglossal muscle of anesthetized cats with two minutes of repetitive hypoglossal nerve stimulation only during severe hypoxia (arterial P02 < 40 mm Hg), but not during mild hypoxia or hypercapnia. The endurance of cat pharyngeal muscles was greater than that of the diaphragm, while in a study of rats, endurance of upper airway muscles was less than that of the diaphragm. Interdependence of pharyngeal muscles in elderly rats was less than that of young rats. This finding could relate to the higher prevalence of OSA in the elderly. The human genioglossus muscle was found to be fatigueable, but no comparison was made with the diaphragm in these studies.

Histochemical studies in animals show that pharyngeal muscles have a much lower proportion of slow-twitch, fatigue-resistance fibers than the diaphragm. In contrast, the pharyngeal muscles have a higher proportion of fast-twitch, relative fatigue-sensitive fibers than the diaphragm. As Teculescu and Vespignani point out, these intrinsic properties of pharyngeal muscles may influence the propensity for the upper airway to collapse during sleep. This theory could be tested in an animal model with chronic resistive loading studies.

In summary, new data are becoming available that were not covered in my review article that may eventually show the importance of the intrinsic properties of the upper airway respiratory muscles in the pathophysiology of OSA. Of course, the difficult question to resolve in these studies is whether the changes observed are primary or secondary, and whether in the human, upper airway histologic changes or potential inspiratory muscle fatigue actually play a part in upper airway collapse during sleep.

REFERENCES

3 Petrof BJ, Pack AI, Kelly AM, Eby J, Hendricks JC. Structural abnormalities of a pharyngeal dilator muscle in dogs with obstructive sleep apnea. ARR 1993; 147:A767
11 Hollowell DE, Suratt PM. Fatigue of the genioglossus produced by inspiratory loading in normal subjects [abstract]. AARD 1988; 137:75

Respiratory Drive in Nonhypercapnic Obese Patients With Sleep Apnea

To the Editor:

We have read with great interest the article by Gold et al. which appeared in the May 1993, issue of Chest. They noticed that patients who are nonhypercapnic and obese with sleep apnea syndrome (SAS) had a lower ventilatory response to hypercapnia (slope Ve/PETCO2) than patients who were nonhypercapnic and obese without SAS; hypoxic ventilatory response was not different between the groups.

At variance with the authors, concordance of these findings with the previous literature is only partial. Although the ventilatory response to hypercapnia is depressed in hypercapnic patients with SAS, it is doubtful in normocapnic SAS subjects. Lopata and O'Neal have shown normal slope Ve/PETCO2 in normocapnic SAS patients. Studies by Rajagopal et al. in nonhypercapnic SAS have shown normal hypercapnic ventilatory response, while White et al. have shown a reduced ventilatory response to hypercapnia and...
hypoxemia. Thus, some controversy exists about the sensitivity to carbon dioxide in nonhypercapnic SAS patients.

Some of these conflicts probably are a result of the obesity that is more commonly found in SAS patients. In obesity, mass loading of the chest wall and abdomen leads to lower functional residual capacity, expiratory reserve volume, and chest wall compliance.6 Also, lung compliance is reduced by the increased pulmonary blood volume, pulmonary hypertension, atelectasis, and excess extravascular lung water.7 Finally, changes in body configuration due to obesity cause respiratory muscles to function at low efficiency at an unfavorable part of their length-tension curve.7 For a given stimulus level, the degree of ventilation depends not only on the nervous system response but also on the state of the respiratory system. Because compliance and inspiratory muscle strength are low in obese patients, ventilatory response must be low, even if the nervous system responds normally or more briskly than normal to the stimulus.

The SAS patients studied by Gold et al have a lower total lung capacity than their control group. This finding only can be explained by a compliance or inspiratory muscle strength decrease. Thus, ventilatory response may fail to reflect the true output at the respiratory centers, requiring other measures, such as muscular response assessed by mouth occlusion pressure (P0.1).8 or neural response, assessed by diaphragmatic electromyographic activity (EMGd).9 Occlusion pressure permits us to note if a low ventilation is from a decrease in neuromuscular output or in respiratory pump. A discordance between ventilatory and P0.1 responses to carbon dioxide has been shown in obese patients.8 Nevertheless, problems with the P0.1 also can arise when pleural pressure is not accurately transmitted through the lungs at the pressure transducer or when the end-expiratory level is different from the relaxed functional residual capacity.10 Reports on the P0.1 response to hypercapnia in normocapnic SAS patients are sparse and conflicting.5 To our knowledge, there is not any report on the neural response (EMGd) to hypercapnia in this group of patients. We think that it is necessary to study chemosensitivity of nonhypercapnic obese patients with SAS by means of P0.1 and, principally, EMGd.

Francisco Garcia Rio, M.D.,
Jose Maria Pino, M.D.,
Salvador Diaz, M.D.,
Carlos Villasante, M.D., and
J. Villamor, M.D.,
La Paz Hospital,
School of Medicine,
Autonoma University,
Madrid, Spain

REFERENCES

To the Editor:

The letter of Garcia Rio et al raises again an unresolved question in the study of ventilatory control. Do some morbidly obese individuals with sleep apnea hypoventilate because they can’t breathe or because they won’t breathe?1-5 The morbidly obese patient’s impaired ventilatory apparatus complicates the study of his ventilatory chemosensitivity. For this reason, our study of the ventilatory responses to chemical stimuli in moderately obese sleep apnea patients who can breathe may be helpful. The study’s findings may also be applicable to morbidly obese sleep apnea patients.

Garcia Rio et al suggest that the small difference in the total lung capacity (TLC) between our sleep apnea patients and controls represents a difference in lung/chest wall mechanics that could limit our patients’ ventilatory responses to hypercapnia (HVR). If true, our conclusion that sleep apnea patients have a reduced sensitivity to hypercapnia is weakened. It seems unlikely, however, that a small difference in TLC caused a significant difference in our patients’ HVR for two reasons. First, inspiration during the HVR test begins at the patient’s functional residual capacity (FRC). Because the FRC is reduced in obese individuals, the lung volume at end-inspiration should remain well below an obese patient’s TLC. Second, the level of hypercapnia that we induced during HVR testing was within our patients’ demonstrated ability to ventilate. We ended the HVR test at a PETCO2 of 65 mm Hg. This resulted in a peak minute ventilation of 55 to 70 L/min for most of our patients. Our patients’ maximal voluntary ventilation of 96±40 L/min was not different from that of controls and adequate for the maximal ventilation required by our HVR testing. Thus, we believe that our sleep apnea patients can breathe, and that their lower HVR indicates that they will not breathe.

Our conclusion that moderately obese patients with sleep apnea have a reduced sensitivity to hypercapnia is also supported by additional evidence. The sleep apnea patients in our study exhibited a higher waking PaCO2 than the controls. These findings were obtained under basal conditions where the ability to hyperventilate was not an issue. This evidence supports our conclusion that these patients won’t breathe. The results of this study in moderately obese sleep apnea patients lead us to speculate that a reduced sensitivity to hypercapnia also contributes to the hypoventilation of morbidly obese individuals with sleep apnea (Pickwickian syndrome).

Avram R. Gold, M.D.,
SUNY Stony Brook,
Northport VA Medical Center,
Northport, New York

REFERENCES
1 Hackney JD, Crane MG, Collier CC, Rocksw S, Griggs DE. Syndrome of extreme obesity and hypoventilation: studies of etiology. Ann Intern Med 1959; 51:541-52