Obesity: Implications for the Clinical Practice of Pulmonary, Critical Care, and Sleep Medicine

Written by Charles Bankhead

Obesity has a multitude of adverse effects on the lungs, many of which remain poorly understood, according to speakers at a session that was devoted to various aspects of the problem. Virtually all of the knowledge relates to obesity's effect on pulmonary function, said Greg King, MB ChB, PhD, Woolcock Research Institute, Sydney, Australia. Though structural effects are widely suspected, scant evidence exists to support the suspicion.

In contrast, obesity's effects on lung function have been documented in multiple studies. The emerging clinical picture consists of preserved FEV_1/FVC ratio, small airway caliber, increased airway closure that occurs during tidal breathing that leads to reduced oxygen saturation (particularly in supine posture), and suggestions of decreased compliance in the lung and chest wall [Pelosi P et al. *Anaesth Analg* 1998; Douglas FG et al. *J Appl Physiol* 1972; Zerah F et al. *Chest* 1993].

Obese individuals have reduced lung volume and reduced airway diameter at rest. With increasing obesity, there is reduced compliance throughout the respiratory system. The increased stiffness seems to be more related to reduced compliance in the lung than in the chest wall, said Dr. King.

Obesity also is associated with clinically relevant airway closure and increasing flow limitation. Airway smooth muscle function could be altered in obese individuals, given their impaired bronchodilatory responses to deep inspiration; however, the effect on airway hyperresponsiveness is minimal since the association between obesity and airway hyperresponsiveness is weak. With respect to clinical consequences, recent studies have shown that obesity is a risk factor for asthma diagnosis and asthma severity [Buether DA and Sutherland ER. *Am J Respir Crit Care Med* 2007].

"Obesity has a dose-dependent effect on the risk of developing asthma," said Anne Dixon, BM BCh, University of Vermont, Burlington, Vermont, USA. "The risk is slightly higher for women, and the risk is higher for nonallergic asthma."

Obese mice exhibit increased airway hyperreactivity, and cell counts are reduced in response to allergen challenge [Johnston RA. *Am J Respir Crit Care Med* 2007]. In humans, airway eosinophilia and exhaled nitric oxide are inversely related to body mass index (BMI) [Van Veen IH. *Allergy* 2008].

Dr. Dixon and colleagues examined the effects of bariatric surgery on airway hyperreactivity and inflammation. Among 41 obese asthmatic patients, 21 patients underwent bariatric surgery and bronchoscopy and were followed for at least 12 months [Dixon et al. *In press*]. Comparing patients who had surgery with those who did not, investigators found that bariatric surgery was associated with improved asthma control, improved airway hyperreactivity, increased lymphocyte counts, and increased cytokine production by peripheral CD4 cells. Obesity is not associated with increased lymphocyte-mediated airway inflammation but is associated with improved airway hyperreactivity in nonatopic individuals.

Data from a Canadian community health survey showed that the prevalence of chronic obstructive pulmonary disease (COPD) is significantly increased among obese individuals, defined as a BMI ≥30 kg/m^2, said Denis O'Donnell, MD, Kingston General Hospital, Kingston, Ontario, Canada. Obesity also is associated with decreased operating lung volumes [O'Donnell DE et al. *Am J Respir Crit Care Med* 2001]. Nonetheless, obese individuals with COPD have diminished exercise-induced dyspnea ratings at any given ventilation, reflecting the mechanical advantage of breathing at lower operating lung volumes.

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"Obese COPD patients are more inactive and utilize more health services than normal-weight patients with COPD," Dr. O'Donnell said. "Common pulmonary function tests are influenced by obesity and need to be considered in clinical interpretation."

Cycle exercise endurance and exertional dyspnea are not increased in obese compared with lean COPD patients, despite increased metabolic and ventilator demand. Lower operating lung volumes and increased inspiratory capacity counterbalance the negative mechanical effects of obesity. Additionally, obese patients with COPD appear to benefit from pulmonary rehabilitation to a similar degree as normal-weight patients with COPD [Sava F et al. *BMC Pulm Med* 2010].

An abnormality that is closely associated with obesity is abdominal compartment syndrome, which is an abnormal rise in intraabdominal pressure (IAP). Normally, IAP is a steady-state pressure (0 mm Hg). The condition arises from the intransient response of the skeleton to weight gain and the gradual stretching of the peritoneal cavity. When IAP reaches 12 mm Hg, a patient has intraabdominal hypertension.

"Acute abdominal compartment syndrome occurs when a patient has sustained intraabdominal pressure exceeding 20 mm Hg in association with new organ dysfunction or failure," said John D. Kress, MD, University of Chicago, Chicago, Illinois, USA.

Chronically elevated IAP is closely associated with obesity-related comorbidities [Sugerman HJ et al. *J Intern Med* 1997]. IAP correlates with sagittal abdominal diameter, a measure of visceral obesity. In a study of morbidly obese patients who were undergoing surgery, mean IAP was 12 mm Hg and was associated with increased rates of gastroesophageal reflux disease, stress urinary incontinence, diabetes, hypertension, and venous insufficiency as compared with a control group of normal-weight patients that had a significantly lower mean IAP ($p<0.02$) [Lambert DM et al. *Obes Surg* 2005]. Moreover, IAP continued to increase in the early postoperative period, reaching a maximum of 15 mm Hg on postoperative Day 2.

An evaluation of mortality risk among intensive care unit patients showed that abdominal obesity was a better predictor of mortality than BMI [Paolini JB et al. *Crit Care Med* 2010]. Sagittal abdominal diameter appears to be a better indicator than BMI with regard to elevated intraabdominal pressure, occurrence of abdominal compartment syndrome, and mortality.

Although difficult to achieve, weight loss can help improve pulmonary function in obese individuals. Several lifestyle changes (ie, increased physical activity, decreased energy intake, increased consumption of fruits and vegetables; small, realistic, achievable goals) have consistently shown potential for effecting weight loss, according to Susan J. Bartlett, PhD, McGill University, Montreal, Quebec, Canada.

"A reasonable initial goal for weight loss is 10% of body weight," said Dr. Bartlett. "If that is successful, further weight loss can be attempted, if it is warranted. A reasonable weight loss goal is 1 to 2 pounds per week."

Establishing good lifestyle practices in children plays a major role in maintenance of those habits in adulthood. Examples of small but effective steps include eating at home (instead of out) more often, sitting down as a family for meals, and eliminating flavored milks and sugary drinks. Physical activity of some sort should be built into the daily routine, and restrictions should be placed on computer and television time.

Bariatric surgery has demonstrated the ability to achieve dramatic weight loss that also is durable in many instances. Recently, numerous studies have shown that surgically induced weight loss is associated with multiple health benefits, said Matthew T. Naughton, MD, Monash University, Melbourne, Australia.

A randomized comparison of laparoscopic adjustable gastric banding (LAGB) and intensive medical weight loss therapy showed a significant advantage for the surgery. The 2-year mean weight loss was 21.6% of excess BMI with surgery versus 5.5% with medical therapy [O'Brien PE. *Ann Intern Med* 2006]. A meta-analysis of studies of three types of bariatric surgery procedures showed a direct correlation between the amount of excess weight loss and remission of type 2 diabetes. LAGB achieved an average 47.5% loss of excess weight, which was associated with a 47.9% remission rate for diabetes. The corresponding figures for Roux-en-Y gastric bypass were 61.6% and 83.7% and 70.1% and 98.9% for biliopancreatic diversion [Buchwald H et al. *JAMA* 2004].

Several studies have documented resolution of obstructive sleep apnea in obese patients who undergo bariatric surgery. For example, a recent meta-analysis showed that bariatric surgery led to a mean weight loss of 81 kg and a decrease in mean BMI from 50 to 33 kg/m^2, which was associated with a 62% reduction in the mean apnea-hypopnea index score and a decline in continuous positive airway pressure requirements from 11 to 7 cm H_2O [Greenberg DL et al. *Am J Med* 2009].

Swedish investigators showed that bariatric surgery has a favorable impact on the hardest endpoint of all: mortality. A study of 4047 obese patients showed that those who underwent weight loss surgery had a 24% reduction in mortality risk during follow-up for as long as 15 years [Sjostrom L. *N Engl J Med* 2007].