Pulmonary ventilation teaching aid: part 2

Since writing the article titled “Pulmonary ventilation teaching aid” (Stockert B, Adv Physiol Educ 27: 41-42, 2003), we have continued to use the salad tongs and rubber band model to teach ventilation mechanics and several clinical correlates. The original article dealt primarily with normal ventilation mechanics and changes in the lungs, i.e., the rubber bands, that occur with common pulmonary disorders, e.g., pulmonary fibrosis and chronic obstructive pulmonary disease. We have developed several additional clinical correlates related to changes in the chest wall, i.e., the salad tongs. Those clinical examples are presented here. The materials needed for this demonstration are several rubber bands and a pair of metal salad tongs with a hinge (Fig. 1).

If a rubber band is placed around the two arms of the salad tongs, the triangular area between the two arms of the tongs and the rubber band can be used to represent the volume of air in the lungs at a given point in time (Fig. 2). A slight, inwardly directed bend in one of the arms of the salad tongs can be used to simulate some orthopedic conditions that result in restrictive lung disorders. The inwardly directed bend decreases the area within the triangle formed by the arms of the salad tongs and the rubber band (Fig. 3). The decrease in area provides visual confirmation of the decrease in inspiratory reserve and vital capacity seen in people with severe thoracic kyphosis, scoliosis, and Dowager’s hump.

We have asked students to visualize what the effect would be if the hinge of the salad tongs was rusty and hard to move. Most students have little difficulty picturing that the movement of the arms of the tongs would require more muscular effort and the movement would be limited in the available range of motion. This situation provides a mental picture of some of the mechanisms involved in restrictive lung disorders resulting from ankylosing spondylitis and osteoarthritis of the spine. Each of these disorders limits inspiratory movement of the chest wall, makes the movement more difficult to perform, and requires more muscular effort to complete. As a result, people with these disorders generally have an increased work of breathing and decreased inspiratory reserve volume and vital capacity.

Students often have difficulty perceiving that obesity produces ventilation problems. To demonstrate the effect of obesity on ventilation, place the long axis of the apparatus in the horizontal plane with one arm down on a surface and one
Arm pointing up (Fig. 4). Place a small weight on the top arm of the tongs. This combination demonstrates that more muscular effort is required to separate the arms of the tongs, i.e., more muscular effort is required to inhale, resulting in an increase in the work of breathing and/or a decrease in inspiratory reserve volume and vital capacity.

BRAD STOCKERT
Program in Physical Therapy
California State University, Sacramento
Sacramento, CA 95819
bstockert@csus.edu
10.1152/advan.00061.2002

A model for visualizing fluid handling by the gastrointestinal tract

Students often find models useful in learning or reviewing physiological concepts. As a result, we have developed a physical model of the gastrointestinal tract, which is used in the GI sections of our medical and graduate physiology courses to demonstrate ingested, secreted, reabsorbed, and excreted fluid volumes by the human digestive tract in a typical 24-h period.

The model was built on a four-tiered homemade shelving system (Fig. 1) assembled from lumber and other materials obtained from a local home improvement center (a list of materials and assembly instructions can be obtained upon request from the author). The tiered shelves make it possible for fluids to flow between the various containers by gravity when the model is in operation. The containers used for the model consisted of a 2-liter plastic soft-drink bottle filled with water (or water with food coloring added) to simulate the typical 24-h dietary fluid intake (A), a 2-liter clear glass bottle with an outlet containing 1.5 liters of water containing food coloring to simulate 24-h salivary secretion (B), a large funnel to simulate the oral cavity (C), a 5-liter clear glass bottle with an outlet to simulate the stomach containing 1 liter of colored water (the equivalent of the volume of gastric juice produced in 24 h (D), a 10- or 15-liter clear glass bottle or carboy with a side inlet to simulate the small intestine containing 1–2 liters of colored water (to simulate the 24-h production of intestinal secretions (E), a 2-liter bottle with outlet to simulate the liver containing the equivalent of the volume of bile produced in 24 h (0.5–1 liter of colored water (F), a 2-liter bottle with outlet to simulate the colon (H), a 100-ml beaker (I), and a 3-liter bottle (J). The latter two containers are used to show, respectively, the volume of water normally excreted in feces in 24 h and the plasma volume. A small recirculating pump (K) is used to simulate “reabsorption” of fluid from intestine.

The model is operated by first identifying for the students what the containers represent and the volumes of fluid they contain. Then the contents of the “dietary liquids” bottle (A) are poured into the funnel (C). Next, the stopper is removed from the tubing from the “salivary gland” bottle (B) and the “saliva” is allowed to flow into the funnel. These fluids mix in the “stomach” (D), and the combined volume is allowed to drain into the “intestine” (E) by removing the he-
mostat that clamps the connecting tubing. As the fluid from the “stomach” container flows into the “intestine” carboy, the hemostat clamping the tubing from the “liver” (F) and “pancreas” (G) containers is released, simulating the relaxation of the Sphincter of Oddi. As fluids flow into the “intestine” container, the “reabsorption” pump (K) is activated, pumping fluid from the “intestine” carboy into the “plasma volume” container (J). Water is also allowed to drain from the “intestine” carboy to the “colon” bottle (H). After 1–2 liters have drained, 100 ml of fluid are removed from the “colon” into a small beaker (I) to simulate the amount of water normally excreted in the feces. At this time, it is also possible to discuss the volumes of water that are excreted with common diarrhea or with more serious conditions like cholera. The explanation and operation of the model requires ~10–15 min. The only problems we have encountered are an occasional leaky connection and slow “reabsorption” flow from the pump. Students find this demonstration interesting and sometimes humorous (if leaks develop) as they learn and review fluid handling by the GI tract.

David M. Lawson
Department of Physiology
Wayne State University School of Medicine
Detroit, MI 48201
dlawson@med.wayne.edu
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FIG. 1.
Assembled model for demonstrating the volumes of water processed by the human gastrointestinal tract in 24 h. See text for letter identification.