A PERSONAL VIEW

Criticizing a didactic model for teaching respiratory mechanics for high school students

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INTRODUCTION

It is very common to use analogies and didactic models for the explanation of physiological mechanisms (1–3). Briefly, these analogies and didactic models aim to facilitate the understanding of physiological mechanisms by the students, who commonly classify them as difficult to understand and without day-to-day applicability.

Despite being commonly used, it has already been shown that the use of analogies and didactic models can generate misconceptions about certain subjects in students, since such didactic strategies are characterized by excessive simplification of complex physiological mechanisms (4).

Of particular interest to the present paper, respiratory physiology is a part of human physiology that requires the understanding, in addition to those related to biology, of physics concepts. Generation of airflow (inspiratory and expiratory) occurs because of the difference in pressure between alveolar air (intrapulmonary air) and atmospheric air. This pressure difference is generated thanks to the action of the respiratory muscles. Briefly, for inspiration to occur, respiratory muscles responsible for inspiration (for example, diaphragm and external intercostal) contract, resulting in increased thoracic cavity volume. As a consequence, the pulmonary volume also increases, and the intra-alveolar pressure decreases, generating a pressure gradient and, consequently, an inspiratory airflow. With regard to expiration, during quiet breathing, expiration is a passive process, characterized by the relaxation of the respiratory muscles that expanded the thoracic volume in the beginning of inspiration. This causes decrease of the chest cavity volume and increase in the intra-alveolar pressure, which becomes higher than the atmospheric air pressure, generating an expiratory airflow (5, 6). Traditionally, inspiration and expiration are addressed by teachers in a topic of respiratory physiology called respiratory mechanics.

In this paper, we analyze critically a didactic model present in textbooks of high school biology and commonly used to teach respiratory mechanics.

The Didactic Model

Figure 1 represents the didactic model analyzed. In this model, the airways are represented by a rigid hollow tube (usually a straw), the thorax by a rigid vessel, the diaphragm muscle by an elastic membrane (usually a bladder), and the lung is also represented by a bladder.

Critical Analysis of the Didactic Model

The model used to facilitate the understanding of respiratory mechanics presents some inconsistencies that can generate important misconceptions among students.

For example, the action of the respiratory muscles is responsible for increasing the volume of the rib cage and, consequently, the volume of the lungs. Briefly, the action of the diaphragm muscle is responsible for the increase of the thoracic cavity volume in the longitudinal axis and the external intercostal muscles by the increase of the thoracic cage in the lateral-lateral and anterior-posterior axis. Altering these volumes alters the alveolar pressure (this change allows the generation of inspiratory and expiratory airflows). It is noteworthy that the model in question represents only the diaphragm muscle (responsible for the enlargement of the rib cage on the longitudinal axis), neglecting, for example, the action of the external intercostal muscles. In addition, the didactic model does not allow the inference of the action of accessory respiratory muscles, such as scalene muscle, sternocleidomastoid muscle, and abdominal muscles. Furthermore, the representation of the thoracic cavity is made by a rigid structure that, therefore, does not allow the visualization of the changes of the thoracic cavity volume.

Another misconception that can be generated is that, in the model, there is no mechanical coupling between the lung and the rib cage, suggesting that the volume changes occur independently. Briefly, between the visceral and parietal pleuras, there is the presence of a thin layer of liquid that makes every movement of the rib cage accompanied by a pulmonary movement. This very important concept of the relationship between
the pleur is ignored by the didactic model, since the bottle that represents the chest is rigid. Furthermore, the pressure in the pleural space is subatmospheric, even when the inspiratory muscles are not contracting. This negative pleural pressure is mainly caused by mechanical interaction between the lung and the chest wall. At the end of expiration, when all of the respiratory muscles are relaxed, the lung and the chest wall act in opposite directions. The lung tends to decrease the volume by virtue of elastic retraction; the chest wall, at the same time, tends to increase the volume because of the elastic retraction. For this reason, the chest wall acts to keep alveoli open. Similarly, the lung acts to keep the chest wall not distended. Because of this interaction, the pressure is negative in the pleural space. Again, these are ignored in the model.

Finally, the model failed to simplify other important aspects of respiratory mechanics, such as the variation of resistance to airflow. The use of a rigid hollow tube to mimic the airway is not appropriate, because the airways are not rigid, they can suffer bronchodilation or bronchoconstriction. In addition, the use of a single tube to represent the airways suggests that there is a single airway, implying that the total transverse cross-sectional area of the airways is unique, when, in fact, it increases as the ramifications occur. As a consequence, the student cannot visualize that resistance to airflow decreases along the airways.

Despite its utility and value, the didactic model presents conceptual errors that may impair the students’ understanding of respiratory mechanics and generate misconceptions about respiratory mechanics among high school students, if the teacher is not able to identify these errors. Although teachers of respiratory physiology in college and beyond may recognize easily the limitations described here, many teachers at the high school level may not. Therefore, teachers at the high school level who use this model should be aware of these mistakes and draw students’ attention to them.

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C.A.B.d.L., S.P.d.M., R.L.V., and M.d.S.A. conceived and designed research; C.A.B.d.L. prepared figure; C.A.B.d.L. and M.d.S.A. drafted manuscript; C.A.B.d.L., R.L.V., and M.d.S.A. edited and revised manuscript; C.A.B.d.L., S.P.d.M., R.L.V., and M.d.S.A. approved final version of manuscript.

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