Student construction of anatomic models for learning complex, seldom seen structures

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MANY ANATOMIC STRUCTURES and morphological relations are difficult to appreciate because they can be difficult or impossible to dissect. Furthermore, two-dimensional pictures may not replicate the anatomy in three dimensions or communicate how components relate spatially. Accordingly, anatomic models have long been used as educational tools because three-dimensional physical models can be more helpful than two-dimensional images in the learning and retention of anatomy content (1). As an example, Leonardo da Vinci used wax to cast the heart cavities of a bull in the early 16th century (3). In particular, the tracheobronchial tree has been characterized with models by numerous educators (2) as the airways are particularly difficult to visualize.

Although models are often used by educators for teaching complex anatomy, the construction of models by students for learning complex anatomy is seldom reported (2). However, making anatomic casts or models by injecting solidifying substances into organs is an excellent way to provide an inquiry-based, collaborative, and problem-solving activity that enhances the learning of complex anatomy while promoting curiosity, skepticism, objectivity, and the use of scientific reasoning (2).

Accordingly, four students (two rising second-year medical students, a rising senior undergraduate Exercise Science major, and a health science graduate student) worked together to make postmortem anatomic casts of the bronchial tree and pulmonary circulation of donated rat and pig carcasses. Specifically, in the rat, white and red Silastic sealants were injected into the trachea and pulmonary artery, respectively, which clearly differentiated the airways from the surrounding arterioles. In pig tissue, white sealant was injected into the trachea, whereas blue and red sealants were injected into the pulmonary artery and pulmonary veins, respectively. The pulmonary artery was accessed by making a cut at the apex of the heart and sending tubing through the right ventricle into the pulmonary artery. The pulmonary veins were filled by pushing tubing through the cut at the apex of the heart into the left ventricle, past the mitral valve and into the pulmonary veins. Since multiple vessels drain into the left atrium, a clamp was tightened at the base of this compartment to ensure filling of all the veins.

The teachers facilitated this process by asking leading questions to guide the students toward the development of their own conclusions. This required the teacher to focus on concepts using logic, reasoning, deduction, and problem solving. In this endeavor, students had a unique opportunity to become directly involved in the process by designing and performing the procedures. Specifically, students worked together to solve complex problems by asking and answering their own questions using their collective skills at gathering, analyzing, and communicating information. As such, the process was as rewarding as the final outcome.

The casts provided a three-dimensional, clear view of the series of rapidly branching airways and arteries that became narrower, shorter, and more numerous as they penetrated deeper into the lung (Fig. 1, A–F). This relatively simple, inexpensive, and easy to do procedure has important applications for the study of respiratory morphology because it engaged, inspired, and motivated students as well as significantly enhanced their understanding of seldom seen structures.

DISCLOSURES

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AUTHOR CONTRIBUTIONS


REFERENCES


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Fig. 1. A: closeup of the anterior aspect of a rat’s left lower lung lobe. The details of the alveolar sacs (white) and perfusing pulmonary circulation (pink) have been clearly captured by the silicon. Note how the pulmonary circulation is integrated into the alveoli, a phenomenon discussed in the context of respiratory physiolog- y but never seen and seldom appreciated by students. B: the posterior aspect of a rat’s right lower lung lobe stripped of the alveolar sacs. This was achieved by slowly separating the arterioles from the alveolar sacs using fine forceps and then stripping the sacs off of the terminal branches. The photograph is a beautiful representation of the pulmonary arterioles (pink). C: the intermediate lobe of the right lung from a pig. The details of terminal bronchioles (white) and the colored veins (pink) and arteries (blue) are easily visible interlaced with alveoli. D: anterior view of the right diaphragmatic lobe from a pig lung. Note that the branching of the arteries (blue) follows closely with the branching of the bronchi (white), sending arterioles from the center of the lobules outward. The venules (pink) drain back into larger veins and are found more superficially at the septa of the lobules. E: silicon model of the left middle lobe from a pig lung. The bronchi- oles were separated exposing the arterioles (blue) and venules (pink). Note the extensive branching of the pulmonary vasculature and the intricacy of the vessels going to and coming from the alveoli. F: silicon model of the numerous veins (pink) and arterioles (blue) located in the anterior aspect of the left middle lobe from a pig lung. The lobules of the bron- chiole were removed to highlight the extensive branching of the veins and arterioles.