A simple, inexpensive model to demonstrate how contraction of GI longitudinal smooth muscle promotes propulsion

Heidi L. Lujan and Stephen E. DiCarlo

Department of Physiology, Wayne State University School of Medicine, Detroit, Michigan

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Peristalsis is a propulsive activity that involves both circular and longitudinal muscle layers of the esophagus, distal stomach, and small and large intestines. During peristalsis, the circular smooth muscle contracts behind (on the orad side) the bolus and relaxes in front (on the aborad side) of the bolus. At the same time, the longitudinal muscle relaxes orad to the bolus and contracts on the aborad side of the bolus. This activity is propagated over varying distances in the different segments of the gastrointestinal (GI) tract. Peristaltic movements are usually directed toward the anus and are due to the organization of the myenteric plexus, which resides between the circular and longitudinal muscle layers.

It is relatively easy to understand how contraction of the circular muscle behind the bolus and relaxation of the circular muscle in front of the bolus propels the object along the GI system toward the anus. However, how contraction of longitudinal muscle on the aborad side of the bolus promotes propulsion is difficult for students to grasp. To help students understand how contraction of the longitudinal muscle on the aborad side of the bolus promotes propulsion, we used a simple, inexpensive model, a “finger trap” (also known as a Chinese finger trap, a Chinese finger puzzle, Chinese thumb cuff, Chinese handcuffs, and similar alternatives). The finger trap is a simple toy that traps the fingers in opposite ends of a small cylinder woven from bamboo and can be purchased online from a number of novelty toy suppliers or through amazon.com. Each student received a finger trap and marble (Fig. 1), and the instructor used a much larger (~5 ft long) version of a finger trap (Fig. 2). Specifically, the instructor used a Jacket Rod Cover (Stick Jacket Rod Cover) that is constructed (woven) like a finger trap and maintains similar functional properties (i.e., the braided polyethylene filament behaves much like the finger trap). Its intended use is to fit over fishing poles to prevent rod tangles. The Jacket Rod Cover can be purchased online from various fishing supply companies or through amazon.com.

To use this model, students were first told that when the longitudinal muscle contracts, the segment shortens (Fig. 3, A and B). Shortening of the segment enlarges (widens) the lumen, and the marble rapidly falls out.
reducing the resistance to propulsion. Students confirmed these statements by pushing the ends of their traps together and noting the widening of the lumen (Fig. 3, C and D). Next, students held the trap vertically and dropped a marble into the top opening (Fig. 1). As expected, the marble quickly became stuck within the lumen of the trap. Subsequently, shortening of the segment by pushing the ends of the trap toward the middle enlarged (widened) the lumen, and the marble rapidly fell to the floor and bounced about the room.

After this explanation and demonstration, students were shown that when the ends of the Jacket Rod Cover were pushed toward the middle, the lumen enlarged. Specifically, to demonstrate this concept, the Jacket Rod Cover was suspended on an IV pole, and a 27-mm rubber ball was dropped into the opening at the top (Fig. 2). As expected, the ball quickly became stuck within the lumen of the model. Subsequently, shortening of the segment by pushing the ends toward the middle enlarged (widened) the lumen, and the ball rapidly fell to the floor and bounced about the room.

This simple and inexpensive model, which required only seconds to demonstrate, helped to focus attention and break the monotony of a lecture while demonstrating an important and difficult to grasp concept. Furthermore, a simple working model is in itself more engaging and inspiring than copious content delivered from someone’s mouth (1). Accordingly, activity-based models are valuable for nurturing our students’ innate propensity and desire to learn. Finally, because much of the GI wall contains both an outer longitudinal muscle layer and an inner circular muscle layer, a thorough understanding of how these muscle layers interact to cause propulsion is important for understanding GI motility.

DISCLOSURES

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AUTHOR CONTRIBUTIONS

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REFERENCE