Design of Esophageal Stent with Decreased Migration

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Goals
1. Design a stent or stent-like device that
   a. Separates the esophageal lumen from the biological tissue
   b. Decreases stent migration
2. Develop testing methods to validate stent designs

Background

The Esophagus
- Lumen: canal of the esophagus
- Muscosa: protective mucosal layer of stratified cells
- Submucosa: layer of mucous-secreting glands
- Muscularis externa: 2 layers of circular and longitudinal muscles

Esophageal Disorders
- Esophageal cancer: Tumors invade the lumen and prevent swallowing
- Esophageal perforation: hole in the esophagus
- Trocheo-esophageal fistula: hole between the esophagus and trachea, causing aspiration
- Brenn sign: scar tissue, often caused by acid reflux

Why Stents?
- Palliation care for inoperable cancers
- Alleviation of dysphagia

Types of Stents
- Normal usage of a stent
- Bare metal
- Partially covered
- Fully covered
- Plastic

Problems with Current Stents
- Migration into lower GI tract: occurs up to 35% of cases for some stents
- Esophageal perforation due to stent: increases risk of infection and further complications
- Incorrect deployment of stent: could require additional procedures to correct positioning
- Injury during removal: no esophageal stent is currently indicated for removal. However, certain cases require removal.

Mechanisms of Stent Migration

Basics of Swallowing
- (1) Food is moistened into a bolus.
- (2) The bolus moves past the upper esophageal sphincter.
- (3) Peristalsis then carries the bolus down the esophagus.
- (4) The lower esophageal sphincter opens to allow the food into the stomach.
- (5) The bolus is digested in the stomach.

Primary peristalsis
- Consists of involuntary muscle movements
- Longitudinal muscles contract ahead of the bolus (detail)
- Increases the diameter of the lumen and the concentrates circular muscles around the bolus
- The circular muscles contract above the bolus
- Completely excludes the lumen and pushes it down into the wider lumen
- Further down
- The peristaltic wave moves at a velocity independent of the bolus

Secondary peristalsis
- A natural reflex of the circular muscles to accommodate lower food passed over by the peristaltic wave
- Depends on continued distention of the esophageal tissue
- Independent of any neuronal activity and can be induced in vivo

Esophageal Propulsive Force (EPF)

This image shows a normal peristaltic wave moving down the esophagus towards the stomach (vertical and horizontal) showing the motion of the peristaltic wave in time (bottom). Note that these are peristaltic waves immediately above and below the bolus. Two peristaltic waves represent the peristaltic wave for the bolus. Once the bolus is defined (35), the peristaltic wave continues down the esophagus.

Possible Esophageal Responses to Stent Placement

References