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
- Cumen – canal of the esophagus
- Muscular – protective mucosal layer of stratified cells
- Submucosa – layer of mucous secretory glandular cells
- Muscularis interna – 2 layers consisting of circular and longitudinal muscles

Esophageal Disorders
- Esophageal cancer - Tumors occlude the lumen and prevent swallowing
- Esophageal perforation - holes in the esophagus
- Tracheo-esophageal fistula – a hole between the esophagus and the trachea, causing aspiration
- Benign strictures - scar tissue, often caused by acid reflux

Why Stents?
- Palliative care for inoperable cases
- Allows for normal swallowing

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

Problems with Current Stents
- Stent 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 masticated 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 (distal)
- Increases the diameter of the lumen and the concentrates circular muscles around the bolus
- The circular muscles contract above the bolus
- Completely occludes the lumen and pushes it down into the wider lumen further down
- The peristaltic waves move at a velocity independent of the bolus

Secondary peristalsis
- A natural reflex of the circular muscles to accommodate leftover food passed over by the peristaltic wave.
- Depends on continual dissolution of the esophageal tissue.
- Independent of any neuronal activity and can be induced ex vivo.

Esophageal Propulsive Force (EPF)

- The esophageal propulsive force (EPF) is a stronger, sustained muscular reaction to an inmovable bolus.
- Results from diameters larger than those resulting in secondary peristalsis.
- Consists of a single, sustained force by the circular muscles
- Can be substantially larger than that resulting from primary or secondary peristalsis.
- Could contribute significantly to stent migration

Distortion thresholds to induce secondary peristalsis (intrathreshold), patient discomfort (pulsion threshold), and maximum tolerable sensation

Possible Esophageal Responses to Stent Placement

References
- [Website Link]
- [Website Link]
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