Non-Operative Correction for Long-Gap Esophageal Atresia (LEA)

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1. INTRODUCTION

About 1000 infants a year in the US are born with their esophagus disconnected, which is called Esophageal Atresia (EA). The standard operation for EA is Foker process \cite{1}, which requires thoracotomy for placement of traction sutures on each esophageal end so as to apply pulling force to stimulate esophagus to grow. There has been a research by Hendren et al. \cite{2} to correct EA by using electromagnetic force: putting two ferromagnetic “bullets” into esophageal pouches and apply external magnetic fields to generate magnetic force. Zaritzky et al. \cite{3} have used permanent magnets to correct short-gap esophageal atresia.

In this research, a non-operative correction method for long-gap esophageal atresia is proposed. Two devices will be put into proximal and distal esophageal pouch. The devices apply normal force, which consists of magnet force and mechanical pushing force, on the esophageal pouch. Pushing mechanism is designed to generate more force in addition to magnet force in the long-gap region. The devices contain pressure measuring fluid which is fed by an external syringe pump. The fluidic pressure is measured by external pressure sensors, so that the devices apply controlled force on the esophageal pouches.

2. PROCESS DESIGN

The operation process for LEA consists of three steps: contact, anastomosis, and retrieval. In the contact phase, the two devices apply normal force on each esophageal end to stimulate the esophageal tissue for growth, thereby making the two esophageal ends meet at one point. Two force sources are used: magnetic force and mechanical pushing force. Mechanical pushing force compensates the magnetic force in the long-gap region, since the magnetic force rapidly decreases as the gap size increases. The advantage of magnetic force is that it always generates force that makes the two devices meet at one point, which approximately functions as kinematic constraint.

Once the contact of two esophageal ends achieved, large normal force needs to be applied to leads necrosis of the sandwiched esophageal tissue. Magnetic force generates large force during the anastomosis phase since the force exponentially increases as the gap size decrease, which is appropriate for anastomosis.

Once the anastomosis is achieved, the device should be retrieved. More fluid can be injected into the device, which functions as standoff between two magnets decrease the magnetic force. Once the magnetic force is decreased sufficiently, mechanical pulling force can detach the devices completely.
3. DEVICE DESIGN

The device consists of three main parts: magnet assembly, fluidic system, and friction drive. The magnet assembly is designed based on syringe mechanism, in which the plunger is comprised of ring type permanent magnets. Pressure measuring fluid is fed through the hole and fills the region between barrel and plunger. The central hole of the ring type magnet is the only channel that the fluid can flow in and out.

The fluid is fed into the device through a long tube, which has a bifurcation at the external end. One end is connected to syringe pump, which can inject fluid into the device, and the other end is connected to pressure sensor, which can estimate the force on the esophagus pouch from the measured pressure.

The friction drive applies shear force on the outer wall of the tube, so that the device can generate mechanical pushing force in addition to magnetic force. The friction drive consists of electric motor, driving wheel, and idler wheel. The electric motor can push forth or pull back the tube, based on the measured force on the esophagus pouch.

REFERENCES

