Expandable Nasogastric Tube

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Background

A nasogastric (NG) tube is a medical device used either for delivery of nutrition/ medication to the stomach or for the aspiration of gastric contents. This project is focused on NG tubes used to aspirate gastric contents. These NG tubes are used to relieve pressure in the stomach/bowels when an obstruction is present and remove gastric contents before gastrointestinal operations are needed.

To remove stomach contents, a NG tube is inserted into the nostril and is navigated through the nasal passageway, down the esophagus, and into the stomach. Once in place, wall suction is used to aspirate the gastric contents. Proper placement in the stomach is confirmed by measuring the pH, X-ray, or by pushing air into the NG tube and using a stethoscope to listen for air in the stomach. The patient will wear this NG tube anywhere from a few hours to one week. If continued treatment is needed, another NG tube is inserted through the opposite nostril, as extended use in the same nostril can be painful and irritate nasal tissue.

Several aspects of an NG tube can cause discomfort to the patient. NG tubes are 4-6 mm in diameter, often making insertion uncomfortable. This diameter is necessary to facilitate suction of semi-solids without causing tube blockage or collapse under the applied negative pressure. However, the large diameter complicates tube insertion with inexperienced practitioners. Current tubes are also susceptible to kinking/coiling in the back of the throat. It is critical to ensure that the NG tube is inserted in the stomach and not into the lungs, as this can cause extensive permanent damage to bronchioles and alveoli.

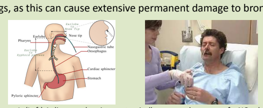

Figure 1: (Left) A diagram showing anatomically correct placement of a NG tube from nose tip, down the esophagus and into the stomach. (Right) A photo of a patient with a NG tube inserted.

Motivation

The insertion process of the NG tube and the feeling of a tube running from your nose to your stomach are unpleasant side effects of NG tube use. The latter is especially aggravated when being worn for longer periods, up to a week. The primary goal of this project is to improve on patient comfort during insertion and long term wear. The large diameter makes insertion difficult and increases patient discomfort during long periods of use. An additional complication that arises with less experienced practitioners is incorrect placement of the NG tube into the trachea or lungs. X-ray is currently used for confirmation, but is an expensive procedure. A lower cost confirmation method is a secondary goal of our project.

Design Requirements

- Minimize patient discomfort during insertion and long-term wear
- Maintain 4mm ID of inner tube to enable aspiration of stomach/small bowel contents
- Use medical grade materials which will not kink or collapse under suction up to 120 mmHg
- Increase ease of insertion for physician
- Provide a method of confirmation of tube placement
- Incorporate recyclable materials where possible

Testing

Inner Tube Recovery After Shrinkage

Method
- Four 5 cm samples of Tygon 100-65 and Sani-tech® 50 in HS tubing
- Measured diameter within HS tube and after its removal
- Averaged 3 points along sample
- Collected at 0, 1, 5, and 10 days after collapse

Figure 2: Cross-section of Sani-tech® sample for recovery test, demonstrating D1 and D2 measurements.

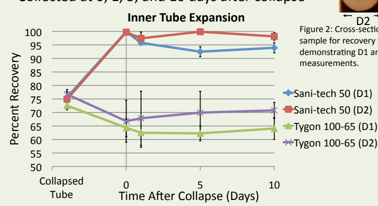

Figure 3: Plot of inner tube recovery after being collapsed in HS tubing for Tygon 100-65 and Sani-tech® 50. Tygon 100-65 melts at heat necessary to shrink tube, causing plastic deformation.

Pressure to Collapse Inner Tube

Method
- Connected inner tube material to hospital wall suction
  - With holes at end (normal flow situation)
  - With holes (blockage situation)
- Tested current NG tube, Tygon 100-65, Sani-tech® 50, Tygon 3550, and SPX-50
- Measured minimum tube diameter with increasing pressure

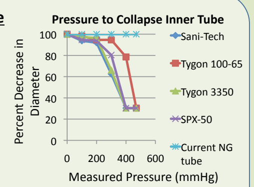

Figure 4: Plot of percent change in diameter with increasing pressure. Current NG tubes do not collapse at any pressure but testing samples collapse although above suction normally used.

Sheath Removal

Method
- Eight 5 cm Sani-tech® samples
  - 1, 2, 5, and 10 mm perforations
  - 2 and 5 mm spacing between
  - 28 gauge steel wire used for removal
- MTS instron at a rate of 50 in/min
- Force and work calculated

Figure 5: Photo of sample with 1 mm perforations with 2 mm spacing (left) and sample with 5 mm perforations with 2 mm spacing (right), demonstrating the bulging rough edge of the larger perforations and full expansion after sheath removal.

Results
- Samples expand immediately when released
- Shrinkage decreases with perforation length
- Average force required to tear perforations: 12.63 N ± 1.68 N
- 1 mm perforation with 2 mm spacing smoothest edge

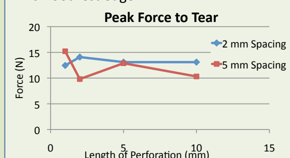

Figure 6: Plot of peak force to tear perforations, illustrating that force is independent of perforation length and spacing.

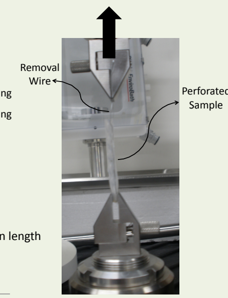

Figure 7: Photo testing setup for measuring force/work to tear HS tubing

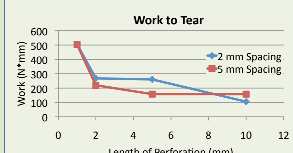

Figure 8: Plot of work to tear perforations, demonstrating that work decreases with increasing perforation length.

Fabrication

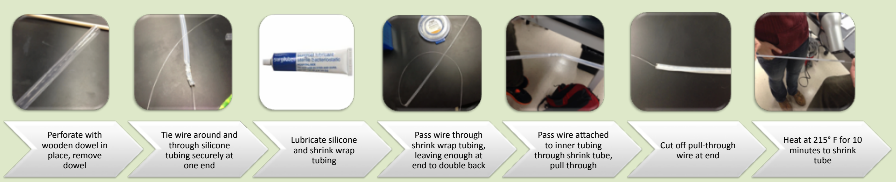

Figure 9: Flowchart illustrating fabrication steps for proof-of-concept prototype

Final Design

Functional inner tube collapsed within a removable shrink wrap sheath

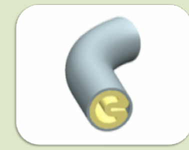

Figure 10: 3D cad model of proof-of-concept cross section

Materials:
- Sheath
  - FEP (fluorenated ethylene polypropylene) heat shrink tubing
  - Wall thickness: .18 mm
  - Initial ID: 5 mm
  - Shrinks at 215° C
  - Shrinks to: D1=3.81mm±0.12, D2=4.51mm±0.09
  - Percent reduction: D1=38.66%, D2=26.27%
- Inner Tubing
  - Medical grade silicone: Sani-tech® 50
  - 5.56 mm OD
  - 3.97 mm ID

Sheath Removal Method
- 1 mm perforations separated by 2 mm of intact shrink wrap tubing
- Wire or twine looped back through tube (material evaluated next semester)

Future Work

- Choose appropriate material for sleeve removal wire or twine
- Manufacture functional prototype utilizing design concept
  - Include closed end with side holes to prevent it from adhering to the stomach
  - Incorporate second lumen
- Optimize wall thickness on inner tube
- Incorporate additional features
  - pH sensor
  - Radiopaque strip

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