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.

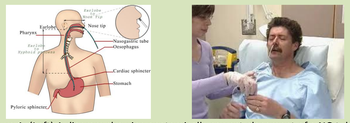

Figure 1: (Left) A diagram showing anatomically correct placement of a NG tube from nose tip, down the esophagus and into the stomach. (Right) A photo of a patient with a NG tube inserted.

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

Pressure to Collapse Inner Tube

Method

- Connected tube 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

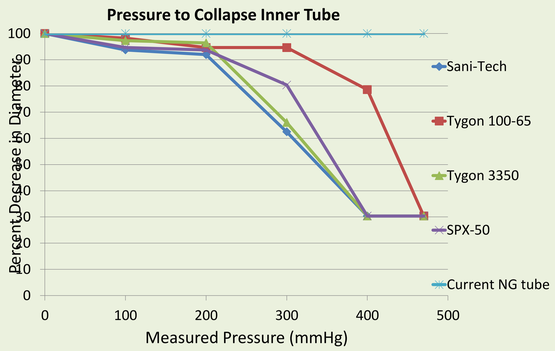

Figure 4: Plot of percent change in diameter with increasing pressure. Current NG tubes do not collapse at any pressure but testing samples collapse although above suction normally used.

Results

- Sani-Tech tubing showed a slight shrinking at intermittent pressures
- Rigidity of current tubing prevented shrinking up to maximum

Expansion of Tube after Pressurized Fluid Insertion

Method

- Inserted fluids from syringes with applied force from hands
- Measured diameter of x and y axes down 15 cm of compressed tube
  - Before insertion as 0% measurement
    - X=4.16 mm
    - Y=5.00 mm
  - Normal tube as 100% measurement
    - X=5.00 mm
    - Y=5.00 mm
- Inserted fluid with 10, 30, and 60 mL syringe
- Fluids used were Air and Water

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

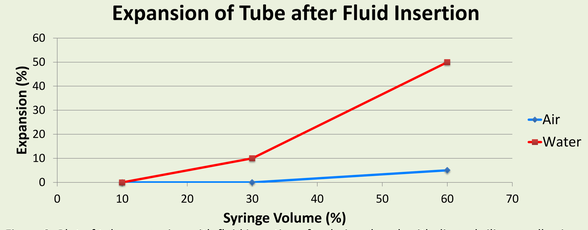

Figure 3: Plot of tube expansion with fluid insertion after being shrunk with die and silicone adhesive.

Results

- Water was much better at expanding tube
  - Expected with incompressible vs compressible fluid
- Only saw 50% as maximum expansion
  - Distension of tube began preventing further expansion

Final Design

Figure 5: Tip design

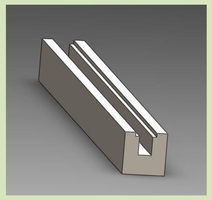

Figure 6. Aluminum Die

Materials:

- Tip/Connector pieces
  - 3D printed using FDM printer
  - Acrylonitrile Butadiene styrene (ABS)
- Distal Tubing
  - Medical grade silicone: Sani-tech® 50
  - 3.97mm ID
  - 10.1mm OD
- Proximal Tubing
  - Medical grade silicone: Sani-tech® 50
  - 5.56 mm OD
  - 3.97 mm ID
- Aluminum Die
  - 2.54cm x 2.54cm x 70cm
  - Top notch – 12.50cm wide x 0.5cm deep
  - Bottom notch – 0.40cm wide x 0.55cm deep

Fabrication

Figure 7: Flowchart illustrating fabrication steps for proof-of-concept prototype

Future Work

- Custom extrude silicone tubing to create a uniform tube
  - Tip built into tubing
  - Silicone tubing tapers from large diameter at distal end to current diameter at the proximal end
- Test the biocompatibility of custom silicone tubing
- Test ease of insertion on medical manikin compared to current NG tube
- Add Radiopaque strip down tubing
- Find more biocompatible silicone adhesive
  - Find best method and more precise way to apply adhesive

Acknowledgments

Advisor: Paul Thompson
Melissa Gershke and the UW Clinical Simulation Facility
Previous Design Teams (Megan Halley, Sarah Czaplewski and Rachel O'Connel, Kelsey Duxstad, Ashley Quinn, Mike Stitgen)
Client: Dr. Steven Yale
Mary Sue Opay
Tara Warner
John Tawil
Dr. John Puccinelli
Professor Timothy Osswald
Susan Olson, RN