Reduced Diameter Nasogastric Tube with Guidewire

Kelsey Duxstad, Rachel O'Connell, Michael Stitgen, and Ashley Quinn
Advisor: Tracy Puccinelli, Ph.D.
Client: Steven Yale, M.D.

Abstract

Nasogastric tubes are used for stomach evacuation and decompression via insertion through the nasal cavity and into the stomach. This is a very uncomfortable procedure for the patient, and could be alleviated with a tube that is inserted with a smaller diameter.. There are two main competitors on the market: a Nano Vibronix tube that generates vibrations during insertion, and a Kimberly-Clark tube that utilizes a silicone balloon to maintain placement in the stomach. Through mathematical analysis and testing we have found that a smaller diameter tube is sufficient for our client's use. This smaller diameter, more pliable tube needs a guide wire to help with placement. When the procedure is completed, the guide wire is removed. Polyvinyl chloride (PVC) and silicone tubing were used in force and suction testing. Testing has shown that this design puts the least amount of pressure on the nasal cavity. Due to risks of chemical leeching from PVC materials, the silicone tubing was determined to be the most effective solution.

Background

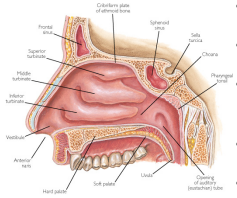

Figure 1. Nasal cavity anatomy and structures encountered by the nasogastric tube.[5]

- Used to decompress the stomach
- Used for one to five days[1]
- ~170,000 nasogastric tubes are placed everyday[1]
- Causes patient discomfort
- Insertion may cause vomiting
- 0.3% death rate due to insertion into lungs[2]

- The nasogastric tub is lubricated with the local anesthetic viscous lidocaine
- Inserted through the nostril and down to the stomach
- Passes through the nasal cavity, nasopharynx, and oesophagus[3].

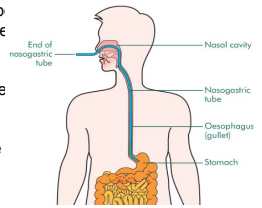

Figure 2. Path of Nasogastric Tube Insertion.[6]

Problem Statement

Our client, Dr. Steven Yale, would like our team to fabricate a nasogastric tube that reduces the patient discomfort during the insertion procedure. To achieve this, the original nasogastric tube diameter of 6 mm will be reduced to 3 mm.

- Cost effective
- Reduces patient discomfort
- Reliable
- Functions at needed flow rate

Final Design

Specifications
- Silicone tubing
- 3.2 mm outside diameter
- Aspiration ports and luer-lock connectors
- Guide wire made of coiled steel used for placement
- Total cost is $21.37
- Cheaper than modified nasogastric tubes on the market

Advantages
- Comfortable
- Inexpensive
- Decreased risk of complications
- Similar to current procedure protocol

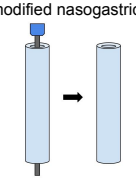

Figure 3. Final design demonstration of the guide wire in silicone tubing.

Item	Cost
Silicone Tubing (4ft)	$4.96
Modifications	$11.41
Guide wire	$5.00

Table 1. Total cost of materials in single prototype: $21.37. Labor for fabrication not included.

Testing

Placement
-Anatomically representative model
-All materials and dimensions successful
-Original NG tube most difficult

Suction
-Ability to withstand suction while in anatomical model
-Suction rate = 600 mL/min
-Average needed clinical flow rate = 1.39 mL/min
-All materials and dimensions successful

Force
-Tested maximum force generated by each of the tubes before kinking
-PVC 3.2 mm outer diameter tubing generated the smallest force

Surface Profile
-Measured surface roughness using profilometer
-Silicone is slightly smoother than PVC

Material	Outer Diameter	Placement with Guide Wire	Suction	Insertion Force	Average Surface Roughness
Silicone	3.2 mm	Easily inserted	Suction with no kinking	1.1631 N	72.24 nm
Silicone	6.4 mm	Easily inserted	Kinks slightly, 50% obscured	N/A	72.24 nm
PVC	3.2 mm	Easily inserted	Suction with no kinking	1.1027 N	85.45 nm
PVC	6.4 mm	Easily inserted	Kinks slightly, 50% obscured	N/A	85.45 nm
Original NG Tube	6.4 mm	Inserted with difficulty	N/A	1.8275 N	136.14 nm

Table 2. Compilation of results for all three tests performed on each of the materials and diameters.

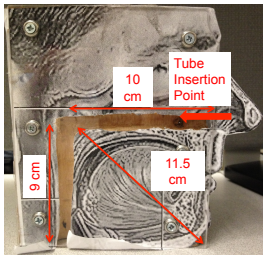

Figure 4. Anatomical model of a nasopharynx made out of wood.

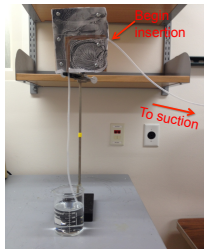

Figure 5. Suction testing setup.

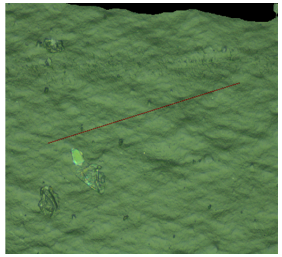

Figure 6. Surface profile of silicone tubing.

Materials

PVC
- Traditionally used for catheters and medical collection bags
- Plasticizers
  - -Soften polymer
  - -Leeching of DEHP (di(2-ethylhexyl)phthalate)[4]

Silicone
- Biocompatible and biodurable
- Stable Si-O bond in backbone[4]

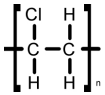

Figure 7. Chemical structure of PVC.

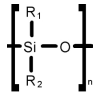

Figure 8. Chemical structure of silicon.

Modeling

- Performed calculations:
  - -Minimum pressure to produce clinical flow rate
  - -Minimum pressure of collapse
    - Safety factor of 2
  - -Deflection index
    - Tubes ability to navigate bend in nasopharynx

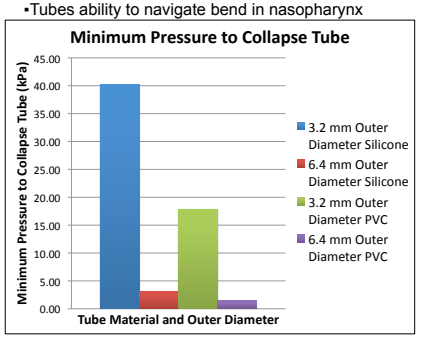

Figure 9. Minimum pressure needed to collapse PVC and silicone tubing of varying diameters.

Future Work

- Modify current manufacturing to work with the smaller diameter silicone tubing (or find a company with these capabilities)
- Research the marketability and patent options for the guide wire tube design
- Research implementation into current medical procedure

Acknowledgements

Dr. Ashton
Dr. Benson
Prof. Chesler
Paula Jarzemsky
Blair Martin
Prof. Masters
Amit Nimunkar
Prof. Osswald
Prof. Pfeffercorn
Prof. Tracy Puccinelli
Dr. Yale
Tobias Zobel

References

[3]Shalamovitz, G. 2011. "Nasogastric Tube." Medscape.
[4] Curtis, J. "A Comparative Assessment of Three Common Catheter Materials." (2008). Dow Corning Company. Web.
[1] Eveleigh, M. "Nasogastric Feeding Tube Placement: Changing Culture." 2011.
[2] Kassias, A. "Perspective Study of Tracheopulmonary Complication Associated with the Placement of Narrow-bore Feeding Tubes." *Critical Care*. 1998.
[5] Seidel, H. *Mosby's Guide to Physical Examination*. New York: Mosby,1999.
[6] Ritchie-Campbell, J. Nasogastric Tube Insertion. Digital image. *Mac Millan*. Web. <http://www.macmillan.org.uk/Images/Cancerinfo/Livingwithcancer/NasogastricTube_2011.jpg>.