

Seminar Presentation Paper Summary

TEP Insufflator
Project #10
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Paper:

1. Kanter, R. K., Pollack, M. M., Wright, W. W., & Grundfast, K. M. (1982, July). Treatment of severe tracheobronchomalacia with continuous positive airway pressure (CPAP). *Anesthesiology*. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/7046516>
Here forth referred to as *Kanter, et al.*

Introduction:

The Tracheoesophageal Puncture (here forth referred to as TEP) insufflator is designed to replace the pre-existing solution to tracheotomy without the patient needing to cover his/her stoma with his/her thumb. The primary purpose of inventing this mechanism is to eliminate the social unattractiveness patients undergo when required to cover their stoma manually. The solution primarily encompasses a CPAP device (used in patients suffering from sleep apnea) to allow a constant flow of breathable air into the patient's stoma. By introducing a CPAP device to enable/disable the airflow into the patient's stoma, we hope to eliminate not only the social unattractiveness caused by the opening in the patient's throat, but also the unnecessary labor required to cover the stoma every time the patient is required to speak/breathe.

The use of a CPAP device is not only brilliant, but also essential for the purposes of this project. As CPAP devices are generally used by patients undergoing sleep apnea, where a common treatment for sleep apnea is tracheostomy¹, it seems logical to treat patients who have undergone tracheostomy with a CPAP machine directly. Research conducted by Kanter et al. focuses on treating tracheobronchomalacia through the use of a CPAP device. "Tracheobronchomalacia is a condition that occurs when the airway walls are weak and the airways collapse during breathing;"² hence, the use of a CPAP device for treating tracheobronchomalacia is similar to that of treating after-symptoms of tracheostomy. In the coming sections, we will summarize the findings of this paper, its relevance to the TEP Insufflator project, and lessons that could be use to improve the current state of the TEP Insufflator project.

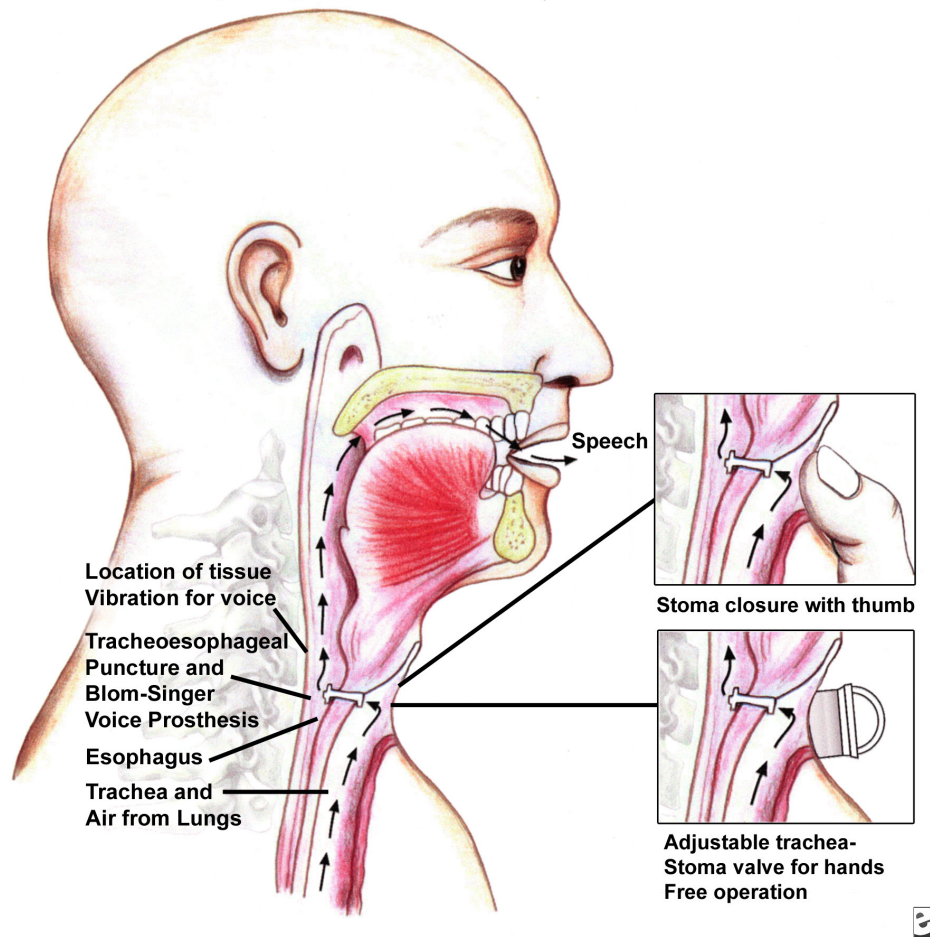
Discussion

The publication submitted by Kanter et al. focuses on an apneic infant suffering from Larsen's syndrome, who at 5 days of age, suffered from respiratory distress resulting in tracheostomy. While the infant performed normally for the next one month, tachypnea

¹ <http://www.webmd.com/sleep-disorders/sleep-apnea/tracheostomy-for-obstructive-sleep-apnea>

² <http://www.mskcc.org/cancer-care/adult/tracheal-diseases/treatment-tracheobronchomalacia>

Tracheoesophageal Voice Prosthesis



<http://emedicine.medscape.com/article/2145329-overview>

and intermittent agitation at 35 days of age. As no signs of infection/bacteria was found and the infant was suffering from distressed ventilation, surgeons implemented the use of a CPAP device to improve air flow. In order to successfully implement the CPAP device, surgeons used a Bourne's infant ventilator to deliver air to the infant's lungs. In order to successfully measure the pressure of air inputted, surgeons installed a latex balloon in the distal third of the infant's esophagus. It should be noted that the esophagus in the human body is adjacent to the location of the voice prosthesis - the attachment behind the primary purpose of this project. A clear representation of this is shown in the image below.

CPAP Device's High Pressure Findings

In order to successfully test the use of the CPAP device, surgeons assessed the pulmonary mechanics at 0 and 8 cmH₂O, respectively. However, as existing CPAP

machines deliver pressure as high as 30 cmH₂O (most machines available on the market have a maximum of 20 cmH₂O), surgeons experimented the benefits of a higher pressure in the infant by raising the pressure from 8 to 14 cmH₂O.

Following the experiment, the surgeons noticed that by raising the CPAP device's pressure to 14 cmH₂O, the infant experienced "relieved distress, increased flow rates, tidal volumes, and minute ventilation, and reduced work of breathing" (Kanter et al.). A detail overview of these findings are shown in the table below (obtained from Kanter et al.). It should be noted that the point of interest here lies on the CPAP device's pressure - as it relates directly to the scope of the TEP Insufflator project. A detailed explanation of this can be found in the upcoming sections.

TABLE 1. Transpulmonary Pressure Change [P_{ip} (I-E)], Peak Flow Rate (PFR), Tidal Volume (TV), Respiratory Rate (RR), Minute Ventilation (VE), and End-tidal P_{CO_2} (P_{ETCO_2}) at Varying Levels of Continuous Positive Airway Pressure (CPAP)

CPAP (cmH ₂ O)	P_{ip} (I-E)*	PFR (I/E)†	TV (ml)	RR (breaths/min)	\dot{V}_E (ml/min)	P_{ETCO_2} (mmHg)	Comment
0	10-16.5	25-35/20-25	8-10	36	300	78	Agitated, distressed
8	2-9.5	30-70/15-50	10-38	54	832	68-76	Agitated, distressed
14	8-9.5	60-90/50-75	20-25	60	1267	49	2 min after CPAP changed to 14 cmH ₂ O, calm
14	1-2	50-60/50-70	25-38	45	1298	49	7 min after CPAP changed to 14 cmH ₂ O, calm

* P_{ip} (I-E) = change in transpulmonary pressure from inspiration to expiration where transpulmonary pressure = measured airway pres-

sure minus measured esophageal pressure (in cmH₂O).
 † PFR (I/E) = Peak flow rate inspiratory/expiratory (in ml/s).

Relevance to the TEP Insufflator

Although the publication conducted by Kanter et al. focuses on the use of a CPAP machine in an infant, the idea behind the use of the machine remains unchanged. In the TEP Insufflator, we strive to achieve a better method of protecting the stoma of a patient who has undergone tracheostomy. Through the use of a CPAP machine, we aim to deliver a pressure strong enough to generate a voice - resulting in the use of a single on/off mechanism that would allow the patient to breathe *and* speak without needing to replace the voice prosthesis or cover the stoma. This application is closely similar to that presented by Kanter et al. as their paper proves the benefits of a CPAP device for patients who have undergone tracheostomy, may they be infants or adults. Likewise, the paper states high levels of CPAP during episodes of tracheobronchomalacia improved pulmonary mechanics and maintained airway patency. Additionally, the paper concludes that CPAP reduces the need for muscle relaxants and mechanical ventilation. As patients undergoing tracheostomy have a voice prosthesis implanted into their

stoma, which must be closed every time they wish to speak, there exists a high possibility of loose cartilage around the walls of the stoma. This usually requires muscle relaxants and proper maintenance to avoid losing the option of using their thumb to cover the stoma. Therefore, by introducing the fact that CPAP reduces the need for muscle relaxants, the study proves that the use of a CPAP device will be highly beneficial to the tracheostomy population.

Conclusion

The paper published by Kanter et al. closely resembles the principles behind treating a trachea/esophageal problem witnessed by over 3,000 americans annually³. As the TEP Insufflator project focuses on improving the lives of those who have undergone tracheostomy, the study published by Kanter et al. proves to be of great importance as it confirms the benefits of a CPAP device in infants. Specific to the TEP Insufflator project, we are focusing on using a CPAP device that can deliver pressures up to 30 cmH₂O. As mentioned in the study by Kanter et al., a pressure of 14 cmH₂O proved to be highly beneficial for infants. We are certain that a pressure of 30 cmH₂O will prove worthwhile and will help in not only generating a voice, but also reducing stress and any social stigma attached to having an open, visible, stoma.

³ http://ic.steadyhealth.com/definition_and_important_facts_about_laryngectomy.html