Balloon vs. Rigid Dilation in Endoscopic Induced Tracheal Stenosis in a Rabbit Model: A Pilot Study
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BACKGROUND
Tracheal stenosis can be an acquired or congenital condition. A common cause of tracheal stenosis is prolonged intubation. Management of tracheal stenosis is challenging. Medical therapy is limited to steroids, systemic epinephrine, and airway monitoring. Surgical treatment includes endoscopic rigid dilation or balloon tracheal dilation, and Tracheal resection. Rigid Dilation is Frequent part of conservative therapy. If it has poor short term results, high failure rates (70%), and frequent returns to operating room. It is not recommended as the first treatment. Balloon Dilation has been reported in pediatric surgery and otolaryngology literature. Anecdotal reports in adult literature treating malignant tracheal stenosis has also been encountered. The question remains: is balloon dilation better or as good as rigid dilation?

OBJECTIVES
1. Create animal model for induced tracheal stenosis
2. Compare balloon versus rigid dilation in treatment of tracheal stenosis

METHODS
Approval for this study was granted by the Georgetown University Animal Care and Use Committee. Six New Zealand Female White Rabbits (NZWR), weight 5-6 kg, with tracheal lumens 0-7mm were divided randomly into two groups: Group A (H101-103), assigned as the Balloon Group, and Group B (H104-106) the Rigid Group. Surgical induction of stenosis was done under general anesthesia. Ketamine 25 mg/kg, Medetomidine M 0.5 mg/kg were used to induce the animals, and a intravenous incision in the anterior neck, the larynx and trachea were exposed. The trachea was incised transversely along the tracheal cartilage with the incised length of two thirds of circumference, 1.5 cm caudal to cricothyroid. A nylon suture was used to suture the tracheal lumen 10 times. Trachea closed with 5-0 monofilament suture. Muscle and skin were then closed with 2/0 monofilament. Animals H105 was lost on postoperative day number 6 from gastronomical. After two weekly endoscopies (using 3/30mm Storz telescopic) insufficient scarring was observed, and decision for Endoscopic reairing was made. Twenty days following the initial surgical attempt at inducing stenoses endoscopic balloon dilation was done using a nylon layered brush and Storz 0° 3.7mm Pediatric bronchoscope. Three Weekly endoscopies were done to follow progression of stenosis on days 29, 36, and 41. Photo documentation was done and Myer Cotton Grading Scale for subglottic stenosis was used to estimate tracheal narrowing. Development of stridor was also documented and followed daily using a Stridor Grading System created by the authors. All animals underwent histologic analysis of the post dilation specimens. All animals underwent histologic analysis of the post dilation specimens. All animals underwent histologic analysis of the post dilation specimens.

RESULTS
Blowing air through an endoscope in the rabbit caused severe subglottic stenosis. A variety of methods of following the severity of airway stenosis was to follow the stridor exhibited by the animals. All animals exhibited some degree of stridor. However, the severity of the stridor varied. Factors such as laryngeal edema and increased secretions caused variation in the amount of stridor observed. Figure 4.

BIBLIOGRAPHY

Follow-up endoscopy was done in 2-2 weeks (day 6), and progression or resolution of stenosis and balloon dilation were documented. Following the procedure all animals were euthanized and underwent hydration of trachea for histopathological evaluation. Specimens were fixed in formalin, and cross sections of the stenotic region were stained in H&E dye. Facial, inflammation, fibrosis, and inner wall thickness was the approximated after microscopic examination. Histo logic evaluation was done by Dr. Kallakury from the Georgetown Univ. Human Tissue Shared Resource (HTSR) Lab.

Grading System for Stridor

Breathing Grade

1. No loud breath sounds, comfortable
2. Minimal breath sounds
3. Mild breath sounds
4. Loud breath sounds
5. Severed breath sounds
6. No breath sounds, respiratory distress

Figure 1. Tracheal stenosis in rabbit animal by endoscopy and a. Pre rigid dilation b. post rigid dilation

Figure 2. Tracheal stenosis in rabbit animal by endoscopy a. Pre balloon dilation b. post balloon dilation

Figure 3. We were successful in inducing tracheal stenosis in rabbit model. Stenosis was seen in all animals in varied degree endoscopic scoring. The stenosis was measured in percentage of luminal stenosis. The stenosis was estimated using the Myer Cotton Classification. All animals underwent histologic analysis of the post dilation specimens. All animals underwent histologic analysis of the post dilation specimens. All animals underwent histologic analysis of the post dilation specimens.

Figure 4. Stridor was present in all animals at post scoring. Stridor score was plotted in the y-axis. There was a correlation between the degree of stenosis and severity of stridor.

Figure 5. Histological evaluation of the post dilation specimens revealed varying degrees of fibrosis among the small group of animals. Overall, the balloon groups displayed slightly lower degree of fibrosis and inflammation compared to the rigid group. There was a correlation with increased focal inflammation among the rigid group compared to the balloon group and control.

DISCUSSION
The treatment of tracheal stenosis has proved itself difficult. Existing dilation techniques yield temporary results, and definitive surgical therapy in form of tracheal resection has variable rates of success. Many of these patients end up with tracheostomies and the accompanying morbidities. Adding a new treatment modality to our armament would be invaluable.

In our pilot study we were successful at inducing tracheal stenosis endoscopically in rabbits. Another method of following the severity of airway stenosis was to follow the stridor exhibited by the animals. All animals exhibited some degree of stridor. However, the severity of the stridor varied. Factors such as laryngeal edema and increased secretions caused variation in the amount of stridor observed. (Figure 4)

Histologic analysis of the tracheal cross sections revealed varying degrees of fibrosis based on the clinical quality of the scar. All specimens displayed inflammation in the form of neutrophils, eosinophils, vascular congestion, and fat necrosis. Group B, however, had slightly higher degree of inflammation seen throughout the tracheal specimen and not just in the area of stenosis. Fibrosis was measured by observing the amount of collagen present in the sub epithelial layer. This collagen was directly proportional to the inner tracheal wall thickness. On average, mild collagen formation was seen in both Group A and B. Although limited by the size of our study, this latter fact indicates both balloon and rigid dilation are equally effective in treating tracheal stenosis. (Figure 5)

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Figure 6. Histologic Analysis: a. Low Magnification H& E slide displaying slightly less degree of fibrosis and inflammation compared to the rigid group. There was a correlation with increased focal inflammation among the rigid group compared to the balloon group and control.

Figure 7. Absolute thickness of the subepithelial layer for Group A and B. no significant difference seen in the two groups.

Figure 8. Histologic Analysis, A. Low Magnification H & E slide showing slight thickness of collagen adjacent to epithelial layer of the trachea. B. Higher Magnification of a slide showing adjacent epithelial layer. Extension of fibrosis seen in a rigid dilation along the tracheal wall in form of multiple neutrophils, eosinophils, and capillary congestion.

Figure 9. Absolute thickness of the subepithelial layer for Group A and B. no significant difference seen in the two groups.

Figure 10. Histologic Analysis, A. Low Magnification H & E slide showing slight thickness of collagen adjacent to epithelial layer of the trachea. B. Higher Magnification of a slide showing adjacent epithelial layer. Extension of fibrosis seen in a rigid dilation along the tracheal wall in form of multiple neutrophils, eosinophils, and capillary congestion.