A Novel Ex Vivo Tracheobronchomalacia Model for Airway Stent Testing and Design Optimization

Objectives: We sought to develop an ex vivo trachea model capable of producing mild, moderate and severe Tracheobronchomalacia (TBM) for optimizing airway stent design. We also aimed to determine the amount of cartilage resection required for achieving different TBM grades that can be utilized in animal models.

Methods: We developed an ex vivo trachea test system which enabled video-based measurement of internal cross-sectional area as intra-tracheal pressure was cyclically varied for peak negative pressures of 20-80 cm of water. Fresh ovine tracheas were induced with TBM by single midanterior incision (n=4) and midanterior circumferential cartilage resection of 25% (n=4) and 50% per cartilage ring (n=4) along a ~3 cm length. Intact tracheas (n=4) were used as control. All experimental tracheas were mounted and tested in the ex vivo model's setup. Helical stents of two different pitch (6 mm and 12 mm) and wire diameters (0.52 mm and 0.6 mm) were also tested in TBM tracheas with 25% (n=3) and 50% (n=3) circumferentially resected cartilage rings. The percentage collapse in the tracheal lumen's cross-sectional area was calculated from the recorded contours for each experiment.

Results: Ex vivo tracheas compromised by single incision, 25% and 50% circumferential cartilage resection produce tracheal collapse corresponding to clinical grades of mild, moderate and severe TBM, respectively. A single anterior cartilage incision produces saber-sheath type TBM while 25% and 50% circumferential cartilage resection produce circumferential TBM. Stent testing enabled the selection of stent design parameters such that airway collapse associated with moderate and severe TBM could be reduced to conform to, but not exceed, that of intact tracheas (12 mm pitch, 0.6 mm wire diameter).

Conclusion: The ex vivo trachea model is a robust platform that enables systematic study and treatment of different grades and morphologies of airway collapse and TBM. It is a novel tool for optimization of stent design before advancing to in vivo animal models.

Abhijit Mondal (1), Gary Visner (1), Aditya Kaza (1), Pierre Dupont (1), (1) Boston Children's Hospital, Boston, MA
Tracheal Test Condition

- 50% cartilage resection
- 25% cartilage resection
- Single incision
- Intact Trachea

Minimum Cross-section Contours as Function of Peak Negative Pressure

![Graph showing minimum cross-section contours as a function of peak negative pressure. Different conditions are represented by lines with markers: Severe TBM, 50% cartilage resection, Moderate TBM, 25% cartilage resection, Mild TBM, Single incision, and Intact trachea. The x-axis represents intra-tracheal negative pressure (cm of water), and the y-axis represents % airway cross-sectional area collapse.](image-url)