RESPIRATORY INVESTIGATION 54 (2016) 237–240

Contents lists available at ScienceDirect

Respiratory Investigation

journal homepage: www.elsevier.com/locate/resinv

Review

Choke point physiology in airway stenting: A case presentation and discussion

Teruomi Miyazawa, Ph.D., M.D.[a,*], *Seiichi Nobuyama, Ph.D., M.D.*[b], *Hiroki Nishine, Ph.D., M.D.*[a], *Hiroshi Handa, Ph.D., M.D.*[a], *Masamichi Mineshita*[a]

[a]*Division of Respiratory Medicine, Department of Internal Medicine, St. Marianna University School of Medicine, 2-16-1 Sugao, Miyamae-ku, Kawasaki, Kanagawa 216-8511, Japan*

[b]*Department of Respiratory Medicine, International University of Health and Welfare Atami Hospital, 13-1 Higashikaigan-cho, Atami-City, Shizuoka 413-0012, Japan*

ARTICLE INFO

Article history:
Received 16 December 2015
Received in revised form
1 February 2016
Accepted 9 February 2016
Available online 20 April 2016

Keywords:
Stent
Flow-limiting segment
Tracheobronchial stenosis
Lateral pressure

ABSTRACT

Background: The point in the airway that allows the smallest maximal flow is known as the "choke point". The tube law describes the velocity of the expired air, which cannot exceed the wave-speed. Flow limitation during forced expiration is affected by the relationship between the transmural pressure (Ptm) and cross-sectional area (A) of the airway. Wave speed is dependent on the stiffness of the airway wall, as well as on the cross-section of the airway itself (dA/dPtm).

Methods: Airway stenting at the wave-speed, flow-limiting segment (choke point) is assessed by using a catheter, via the working channel of a stereoscopic bronchoscope, to measure the difference between lateral pressure and pleural pressure.

Results: Based on the wave-speed concept of maximal expiratory flow limitation, stenting at the choke point increased the cross-sectional area and supported the weakened airway wall, thus improving expiratory flow limitation and relieving dyspnea.

Conclusion: To ensure correct stent positioning and thus optimal functional benefit, it is important to locate the exact position of tracheobronchial stenosis.

Contents

*Corresponding author. Tel.: +81 44 977 8111; fax: +81 44 977 8361.
E-mail address: miyazawat@marianna-u.ac.jp (T. Miyazawa).

http://dx.doi.org/10.1016/j.resinv.2016.02.006
2212-5345/

1. Introduction

The tube law [1,2] describes the velocity of the expired air, which cannot exceed the wave-speed (the speed of a pressure wave passing through the airway segment). The maximal flow that can pass through an airway segment is determined by the following equation: $V'max = A(A/(\rho Caw))^{0.5}$, where A is the cross-sectional area of the airway, ρ represents the density of the air, and Caw is the airway compliance (dA/dPtm). The point in the airway that allows the smallest maximal flow is known as the "choke point". In normal subjects, this is situated in the transition between the intrathoracic and intrapulmonary airways; the choke point moves peripherally during expiration (Fig. 1) [1–6].

2. Materials and methods

Airway stenting at the wave-speed flow-limiting segment (choke point) was assessed using a double-lumen airway catheter (Fuji Systems, Tokyo, Japan), via the working channel of a stereoscopic bronchoscope, to measure the difference between lateral pressure and pleural pressure. The catheter was inserted into the airway during bronchoscopy. The site of maximal obstruction was identified based on the pressure difference between the proximal and distal sites of the stenosis.

The catheter was made of a nylon elastomer and had two holes in the side 5 cm apart; its outer diameter was 1.7 mm. It was connected to two identical pressure transducers (SCX01DN; Sensortechnics, Munich, Germany). During stenting, the patient was administered light general anesthesia, and was allowed to breathe spontaneously; lateral and pleural pressures were measured simultaneously at two points [7]. Pleural pressure was measured using an esophageal balloon catheter.

The diameter and cross-sectional area of the airway were measured using stereoscopic bronchoscopy (BF-Y0006, Olympus, Tokyo, Japan), which involves two lenses at the tip of a flexible fiberscope, and the principle of triangulation.

3. Results

The choke point originally occurred where the cross-sectional area of the airway was the narrowest. After stenting, migration of the choke point to a non-stented segment of the weakened airway resulted in its subsequent collapse. We will briefly discuss a typical case of expiratory central airway collapse (ECAC) with forced expiratory wheezing in a patient with tracheobronchial malacia.

Before stenting, we determined the transmural pressure after measuring the difference between the lateral pressure at the flow-limiting segment and the pleural pressure. Fig. 2 shows repeated airway collapse during the expiratory phase.

Fig. 3 shows the degree of tracheal collapsibility, as well as the transmural pressure and the cross-sectional area of the airway. Before stenting, a slight narrowing of the airway occurred during inspiration, and a severe collapse was observed during expiration, as indicated by a dramatic increase in transmural pressure. The image on the left shows the trachea before stenting, while that on the right displays the trachea after stenting.

Before stenting, the airway wall was narrow, resulting in high driving pressure. After stenting, the airway stiffness was increased, reducing the previous driving pressure, and the

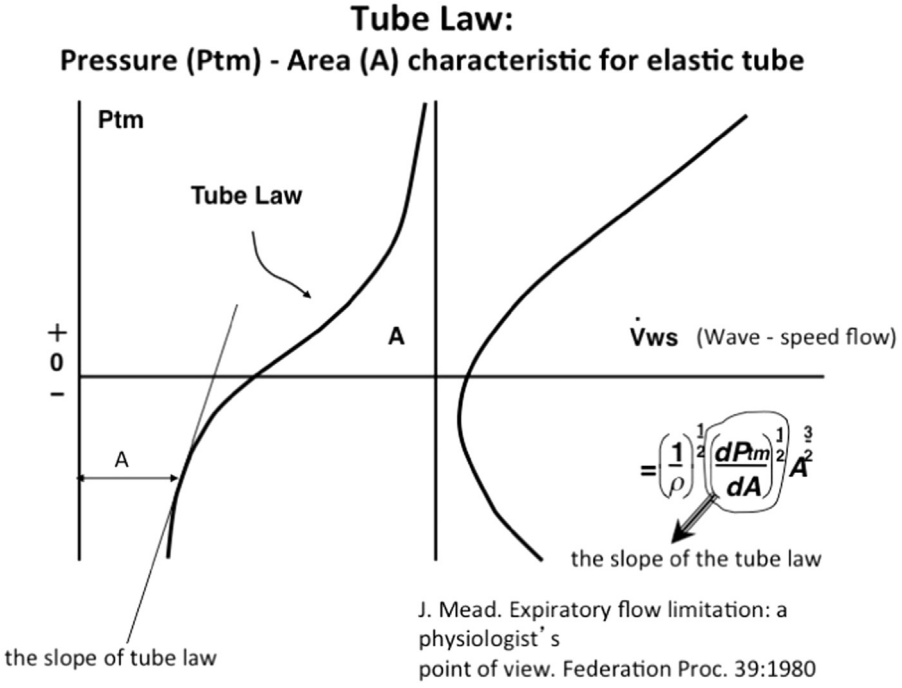

Fig. 1 – Schematic of the tube law.