Analysis of Pressure Distribution During Direct Microlaryngoscopy

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Summary: Objective. This study aimed to investigate the pressure distribution during direct microlaryngoscopy and its relation with the positioning of the patient.

Study Design. This is a prospective study in cadavers.

Materials and Methods. The pressure distribution during direct microlaryngoscopy was investigated in five adult fresh cadavers by using matrix-based piezoresistive thin-film sensors. The pressure among three head and neck positions (extension-extension, neutral, and flexion-extension) was studied.

Results. The real-time pressure and its distribution were recorded as 3-D contours. The map commonly showed two peak pressure points, with one focused on the middle of the laryngoscope (peak pressure 1) and the other one focused on the distal part of the laryngoscope (peak pressure 2). The mean average pressure in this study was 38 ± 13 kPa, and the flexion-extension position had the lowest average pressure and peak pressure. However, the average pressure and peak pressure 1 showed no significant difference among the three positions ($P > 0.05$); peak pressure 2 in the flexion-extension position was significantly lower than that in the extension-extension position ($P = 0.024$) and the neutral position ($P = 0.020$).

Conclusions. The results of this study indicate that the flexion-extension position induced lower pressure exerted on the laryngoscope and is an optimal position for direct microlaryngoscopy. Hyoid bone may play an important role in the pressure exerted.

Key Words: Microlaryngoscopy–Head and neck posture–Difficult laryngeal exposure–Pressure distribution–Hyoid bone.

INTRODUCTION

Direct microlaryngoscopy is the predominantly used technique in laryngology, with the fulcrum-based laryngoscope serving as the most popular instrument. To achieve proper exposure of the vocal fold anterior commissure, the laryngoscope must exert pressure on the tongue and the laryngopharynx.[1,2] The intensity of the pressure may depend on a number of parameters, including the insertion technique, the positioning of the patient, the size and type of the laryngoscope, gender, age, and other unique anatomies of the patient.[3–6] An approximated pressure during direct microlaryngoscopy through the lever principle is calculated in this paper, and it has been found that the pressure applied was extremely high in patients with difficult laryngeal exposure.[2] However, pressure distribution, a very important factor correlated with difficult laryngeal exposure and the presence of postoperative throat pain and complications, has never been investigated. The purpose of the present investigation was to evaluate pressure distribution and its relationship with patient positioning along the length of the laryngoscope during a direct suspension laryngoscopy.

In the present study, we measured a more accurate pressure and its distribution during direct microlaryngoscopy by using matrix-based piezoresistive thin-film sensors, and investigated its relation with the positioning of the patient. Hopefully, the information gathered will show a new way to expose the flaws in direct microlaryngoscopy and provide valuable data for future improvements in direct laryngoscopy techniques and instrumentation.

MATERIALS AND METHODS

The study included a total of five fresh cadavers from the Department of Pathology, Shanghai Medical College, Fudan University, one female and four male donors aged 49–72 years (mean age, 61.2 years; mean body mass index [BMI], 21.2). All the cadavers were accepted within 48 hours, with exclusion criteria as follows: a history of previous neck irradiation, trauma, burns or neck surgery (such as neck dissection), previous severe laryngeal infection, disorders of the tympanomandibular joint, retrognathia, and loose teeth and upper incisors. The maximum head extension of the specimens was over 90° and there were no discernible signs of cervical spinal fusion. The study was approved by the institutional review board, and informed consent was obtained from all the legal representatives of the donors.

A thin-film tactile pressure sensor array model #6300 (Tekscan, Inc., South Boston, MA) was used in the present study. The sensor array was calibrated first using an electronic pressure calibration device that allows application of uniform static pressure levels over the whole sensor area. Then, the thin-film tactile sensor was applied on the upper surface of the direct rigid laryngoscope (Kleinsasser, 8590B; Karl Storz GmbH & Co., Tuttlingen, Germany) with a polythene. When maxillary teeth were present, dental guards were used, and the prepared laryngoscope was passed into the right-hand side of the mouth alongside the tongue and slid behind the base of the tongue in the middle line to expose the epiglottis and the glottis. After lifting the laryngoscope holder and obtaining the visualization of the anterior commissure without external manual

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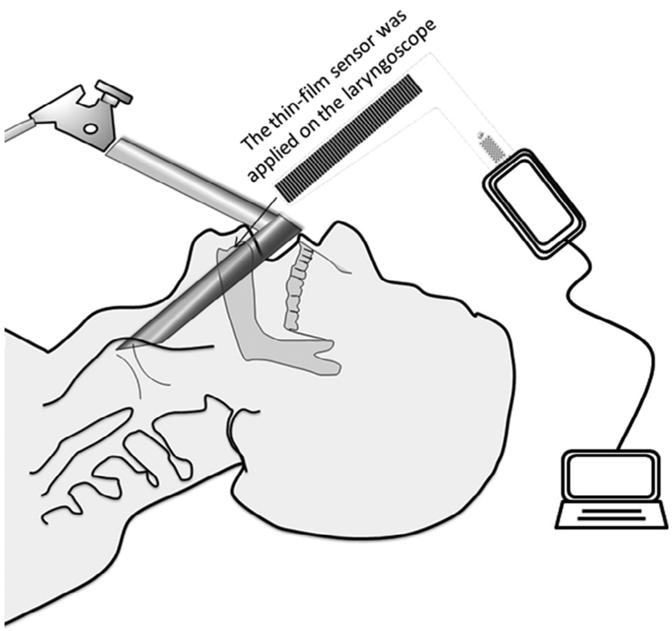

FIGURE 1. Diagram of the laryngoscope and the setup used to measure pressure distribution.

laryngeal compression, the holder device and the chest device were fixed into position. Once the laryngoscope was placed into larynx, the static pressure exerted on the tissue was recorded with the *Tekscan I-Scan* software version 7.50, and the average pressure and peak pressure within the recording time were analyzed (Figure 1). Insertion of the laryngoscope in the fresh cadavers was performed by an experienced laryngologist.

Three head and neck positions were studied. The positions were based on the relationship of the neck to the chest and of the head to the neck: (1) the extension-extension position, achieved by placing a cushion under the shoulders; (2) the neutral position, the head at the same level as the shoulders; and (3) the flexion-extension (sniffing or Boyce-Jackson position), achieved by placing a cushion under the head. A full head extension was ensured in all the subjects; the cushion height was 7 cm.

All data were exported from the *Tekscan I-Scan* system into *Microsoft Office Excel 2007* (Microsoft Corporation, Redmond, WA), and the numerical variable was expressed as mean ± standard deviation. All the variables were quantitative and were analyzed with analysis of variance using *SPSS 18.0* (SPSS Inc., Chicago, Illinois), and a *P* value of <0.05 was considered statistically significant.

RESULTS

The static pressure and its distribution were recorded during direct microlaryngoscopy, and could be displayed as 3-D contours (Figure 2). The pressure 3-D contours commonly showed two peak pressure points, with one focusing on the middle of the laryngoscope (peak pressure 1) and the other focusing on the distal part of the laryngoscope (peak pressure 2). The mean average pressure in the present study was 38 ± 13 kPa. Table 1

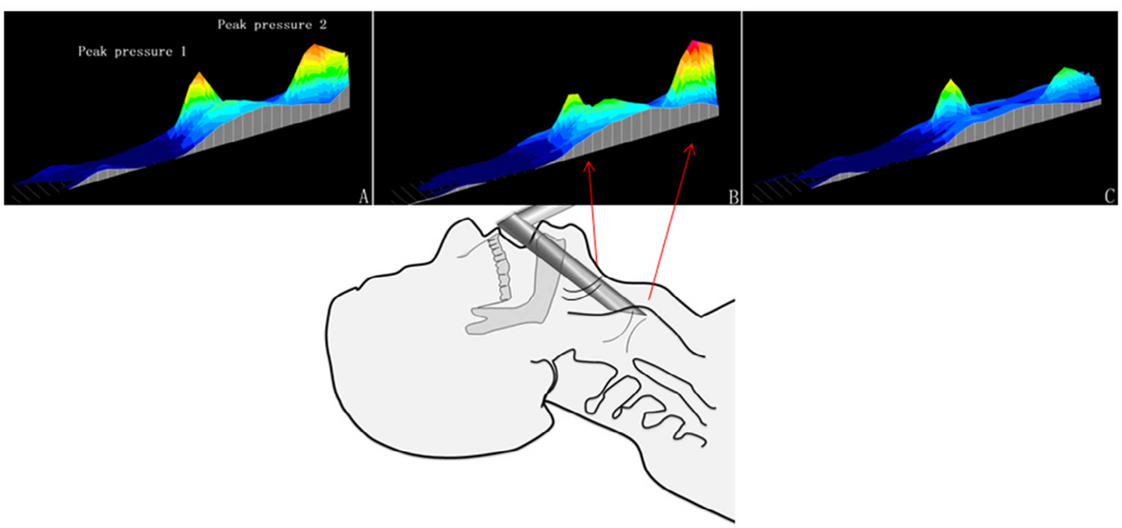

FIGURE 2. A typical pressure distribution shown as 3-D contours in three positions: (**A**) extension-extension, (**B**) neutral, and (**C**) flexion-extension.

TABLE 1.
Average Pressure and Peak Pressure in Three Different Head and Neck Positions

Pressure (kPa) Mean ± Standard Deviation	Head and Neck Positions: Extension-Extension	Neutral	Flexion-Extension
Average pressure	43 ± 15	39 ± 14	32 ± 10
Peak pressure 1	183 ± 70	150 ± 42	127 ± 43
Peak pressure 2	231 ± 41	238 ± 70	132 ± 68