Forces During Suspension Laryngoscopy: Relationships with Hemodynamics, Anesthetic Requirements, and Patient Factors

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Introduction

Suspension laryngoscopy (SL) is commonly performed, but little is known about forces generated during these procedures. The goal of this study was to identify correlates between patient factors and forces generated during SL as well as effects these forces have on hemodynamic responses and anesthetic requirements.

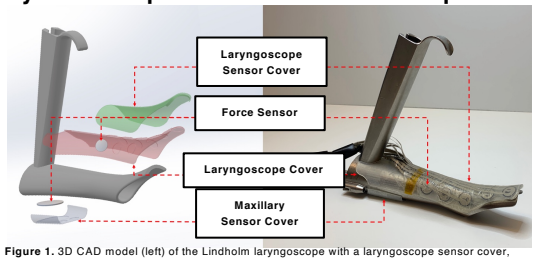

Figure 1. 3D CAD model (left) of the Lindholm laryngoscope with a laryngoscope sensor cover, force sensors, laryngoscope cover, and maxillary sensor cover and the experimental model (right).

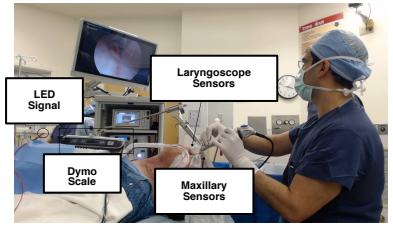

Figure 2. Intraoperative setup involving the laryngoscope force sensors, maxillary force sensors, the Dymo scale, and LED signal.

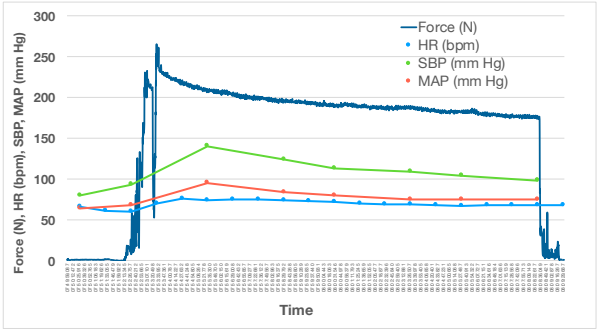

Figure 3. Laryngeal Forces and Hemodynamic Values vs Time for one patient case.

Methods

Patients undergoing SL were recruited at a tertiary care academic center from 7/6/18 to 12/22/20. A force array with 13 sensors along the blade and 3 sensors for the maxilla were mounted on a Lindholm laryngoscope with an additional sensor under the suspension arm. Patient anatomic features, prior treatment, anesthetic data and perioperative data were obtained. Outcomes were forces, hemodynamic changes, and anesthetic requirements.

Table 1. Pearson correlation coefficients between patient characteristics and maximum laryngeal and maxillary forces.
*Strong correlation. These factors were also found to be significant predictors of maximum forces in stepwise multiple regression analysis.

Patient Characteristics	Max Force - Larynx	Max Force - Maxilla
Neck Circumference	0.07	-0.057
Dentition	**0.618***	**0.539***
Mouth Opening	0.284	-0.039
Hyoid to Mentum Distance	-0.401	-0.411
Prior Neck Treatment	-0.105	0.081
Mallampati	0	-0.013
Tumor Location	-0.096	-0.219
Tumor Stage	-0.175	-0.169
Treated Tumor Site	0.059	0.061
Age	-0.215	-0.272
BMI	0.243	0.076
ASA Group	-0.303	-0.378
Airway Grade	0.479	**0.56***

Results

53 patients were recruited (40 male, 13 female), and mean age was 61.9 years. Indications were diagnostic laryngoscopy and resection of benign and malignant lesions.

The mean maximum laryngeal and maxillary forces were 234N and 229N, respectively. The mean % change in mean arterial pressure (MAP) following the initial force stimulus was 52.0. Patients with MAP changes ≥52% were older compared to those with MAP changes <52% (p=0.010). The mean MAP during the case was 95.6 mmHg. Patients with MAP ≥96 mmHg had higher mid-case laryngeal (p=0.019) and maxillary forces (p=0.008).

At 5 and 10 minutes into the cases, forces were higher in patients with ASA scores 1-2 versus 3-4, for the larynx (p=0.012, p=0.027) and maxilla (p=0.041, p=0.029). In multiple regression analysis, only dentition predicted laryngeal forces (p<0.001), while both dentition (p=0.013) and airway grade (p=0.006) predicted maxillary forces. Differences in forces and hemodynamic changes were not seen in patients with different anesthetic techniques.

Conclusions

Dentition and higher airway grades predicted maximum forces measured in SL. Higher forces were associated with higher MAP during SL, and older patients had more hemodynamic instability at the start of SL. Patients with lower ASA scores may have bulkier, less atrophic soft tissue than those with higher ASA scores, requiring greater forces to obtain adequate exposure of the upper aerodigestive tract. Future studies should aim to further characterize how patient factors affect forces and hemodynamic stability during SL. Force arrays may potentially provide real-time feedback during SL to facilitate titration of anesthetics and minimize complications.

References

References are available upon request.