Laser plume containment during flexible transnasal laryngoscopy

Henry T. Hoffman H, MD, MS¹ | Jarrett E. Walsh MD, PhD¹
Alessandra Pratt MS² | Robert M. Miller RM, MS³ | Adam Schwalje MD, DMA¹
Helen R. Stegall BSN¹ | Matt Nonnenmann PhD²

¹Department of Otolaryngology, University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA
²Department of Occupational and Environmental Health, University of Iowa College of Public Health, Iowa City, Iowa, USA
³Engineering Services, University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA

Abstract

Objective: To evaluate a negative pressure microenvironment designed to contain laser plume during flexible transnasal laryngoscopy.

Methods: The Negative Pressure Face Shield (NPFS) was previously reported as well tolerated with initial use on 30 patients. Diagnostic transnasal laryngoscopy was performed on an additional 108 consecutive patients who were evaluated by questionnaires and sequential pulse oximetry. Further study addressed operative transnasal potassium-titanyl-phosphate (KTP) laser laryngoscopy with biopsy done on four patients employing the NPFS.

Results: The previously described NPFS version 3 (v.3), a transparent acrylic barrier with two anterior instrumentation ports, was modified by repositioning the side suction port closer to the level of the nose and deepening the lateral sides, squaring off the lower projection. A post-procedure questionnaire employing a 5-point Likert scale ranging from no symptoms (rating of 1) to intolerable (rating of 5) identified excellent patient tolerance of the new design (v.4), among 22 patients evaluated and similar in the comparison to the 116 patients using version 3. Among the 138 patients analyzed, only one patient rated the experience as greater than “mild claustrophobia.” 100% of patients answered either “none” or “mild” to the pain and shortness of breath questions. The NPFS (v.4) was then successfully used in four patients for laser laryngoscopy with biopsy of laryngeal papilloma (3/4) and hemorrhagic polyp (1/4). Post-procedure questionnaire identified no shortness of breath (4/4), no claustrophobia (4/4), no pain (4/4) and no significant changes in pulse oximetry during use.
**Conclusion:** Extensive experience in performing diagnostic laryngoscopy with the NPFS directed design changes leading to successful use for transnasal flexible laser laryngoscopy with biopsy in a negative pressure microenvironment.

**Level of Evidence:** Level 2b (Cohort Study).

**Keywords**

- biopsy
- COVID-19
- laser
- KTP
- RRP
- transnasal laryngoscopy

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1 | **INTRODUCTION**

High energy surgical devices such as laser and electrocautery produce plumes that contain cardiotoxic and carcinogenic aerosols as well as viable viral contaminants.\(^1\)\(^-\)\(^5\) Efforts to control spread of these substances include recommendations from the Centers for Disease Control and Prevention (CDC) to limit dispersion through use of smoke evacuators containing a suction unit.\(^6\)

Concern about risk of viral transmission associated with aerosol generating procedures (AGPs) has been amplified during the COVID pandemic to intensify efforts to limit dissemination of surgically produced aerosols.\(^7\) Serban et al recently identified that use of filtrations systems “will probably remain a routine also in the future” and that “the effect of COVID-19 pandemic will be most probably a progress in the safety regulations”.\(^8\)

An umbrella emergency use authorization (EUA) was provided by the U.S. Food and Drug Administration (FDA) May 1, 2020 for use of passive protective barrier enclosures (without negative pressure) when performing aerosol producing medical procedures on patients at risk for infection with SARS-CoV-2 in health care settings. This authorization was revoked by the FDA August 20, 2020 due to studies leading to the conclusion there was lack of efficacy and a potential for adverse events.\(^9\)\(^-\)\(^11\)

FDA authorization remains viable for protective enclosures employing suction to create a negative pressure. In a letter (August 21, 2020) to health care providers the FDA identified “If electing to use a protective barrier enclosure for additional protection during aerosolizing procedures by HCPs, FDA recommends the use of devices that incorporate negative pressure”.\(^12\) FDA support (EUA) remains (as of October 4, 2020) for several devices for use “when performing airway-related medical procedures” as barriers to isolate the patient within a negative pressure environment maintained by continuous suction.\(^13\)\(^-\)\(^14\)

The Negative Pressure Face Shield (NPFS) is a protective enclosure employing suction to create a negative pressure microenvironment previously reported to permit diagnostic flexible transnasal laryngoscopy with a high level of patient tolerance.\(^15\) We present additional experience with the NPFS and subsequent minor modifications to the original design permitting study during operative flexible transnasal laryngoscopy with biopsy and laser ablation.

2 | **MATERIALS AND METHODS**

The local institutional review board (IRB) directed and approved the clinical evaluation of the NPFS. All methods were in full accordance with the principles set out by the World Medical Association Declaration of Helsinki. A special IRB approved written consent was obtained from each patient who participated in the study and was supplemented by a second additional approved written consent for those selected patients whose images were depicted in figures.

Testing of multiple prototypes led to development of the NPFS version 3 (v.3) made of 0.2” (5 mm) thick acrylic. This NPFS is a transparent 9” x 10.5” rectangular device with a depth of 3.5” and an inferior stabilization flange used to engage a clamp on a camera stand (Matthews Hollywood Century 40” S Stand for Grip Arm Kit, Adorama Inc., New York, New York) for positioning in front of the patient. The three openings in the NPFS were smoothed and sealed to ensure that these areas would not harbor unwanted particulate matter. These openings included two separate ¼-in. (6.35 mm) access ports in the lower midline of the face shield and a 5/16-in. (7.94 mm) suction port on the mid-lateral surface. The initial design, version 3 was modified to version 4 to deepen the box and place the suction at a lower level closer to the nose and mouth. The added depth was provided to not only increase the distance of the patient from the front of the shield, but also to assess potential use of the lower flange of the box as a chin rest (Figures 1 and 2).

This device was created in the University of Iowa Machine Shop with additional oversight from Infectious Disease, Hospital Epidemiology and Bioengineering Departments in the University of Iowa Hospital.

All diagnostic transnasal laryngoscopies employing the NPFS were done employing standard wall suction (Vacutron Suction Regulators by Chemetron Inc) with a maximum regulated suction of 320 ± 20 mmHg. All operative transnasal laryngoscopies with laser and biopsy were performed employing a portable suction (Neptune 3 Waste Management System 120 VAC Rover, Stryker, Kalamazoo, Michigan) which includes a High Efficiency Particulate Air (HEPA) Filter at continuous suction approximating 520 mmHg. Both suction systems were in accordance with recommendations from the FDA as published for use with the negative pressure “Airway Dome” (Supplement 1, Data S2).\(^13\) Sterile disposable suction tubing (0.6 mm × 3.7 mm, non-conductive suction tubing, 12 ft length; Cardinal Health Waukegan, Illinois) was attached to the NPFS and used for both diagnostic and operative laryngoscopy.

All diagnostic laryngoscopies were performed in a standard examination room designated as having 6 air changes per hour (ACH) employing standard wall suction as designated above. All operative laser laryngoscopies were done in an operating room with 25 to 30 air changes per hour.
The initial 30 consecutive patients evaluated with the NPFS were analyzed in a previous report.\textsuperscript{15} The subsequent 109 consecutive patients who were offered diagnostic trans-nasal laryngoscopy with the NPFS by the senior author (HTH) between May 28th to August 6, 2020 are analyzed in this report and exclude one patient who had no laryngeal symptoms and deferred the examination, leaving 138 patients who agreed to participate in the study. Limited testing at our facility during this period permitted SARS-CoV-2 viral assessment of patients undergoing aerosol generating procedures for which the NPFS could not be used such as tracheostomy change, transoral, laryngoscopy-assisted, percutaneous injection laryngoplasty. The NPFS was used for diagnostic purposes on 116 consecutive patients, employing version 3 (v.3), with the subsequent 22 patients using version 4 (v.4).

Institutional approval was granted August 11, 2020 to use the NPFS clinically in a non-research mode. Following this date, all subsequent use of the NPFS for diagnostic laryngoscopy was done off-study. Operative transnasal laryngoscopies were continued on-study leading to a consecutive series of transnasal flexible laryngoscopy with KTP laser and biopsy on four patients between August 19 to September 23.

As previously reported, a sterilization wrap (Halyard H100 sterilization wrap, O&M Halyard Inc., Alpharetta, Georgia) was fashioned as a cylinder and secured to the NPFS with tape circumferentially.\textsuperscript{15} The wrap was adapted to drape over the patient’s head as a hood to create a closed environment by drawing the lower aspect of the drape loosely around the patient either by using a 3 to 4 ft length of umbilical tie (white twill ½ in., 36-yard roll, Horn Textile Inc., Titusville, Pennsylvania) or, as was more common practice later in the study, tucking the drape into the patient’s shirt without use of twill tape (Figure 3).

Due to concerns about aerosol generation associated with spraying the nose outside of a contained environment, delivery of topical nasal anesthesia (1 cc of a mixture of 4% lidocaine with 1% phenylephrine) was initially done through an anterior access port of the NPFS employing the MADgic Laryngo-tracheal mucosal atomization device (Teleflex Medical, Inc, Morrisville, North Carolina). A recent report by Fink et al identified that administration of medical aerosols from nebulizers do not produce a bioaerosol unless they stimulate a cough.\textsuperscript{16} Our clinical experience has been consistent with this finding and led to use of standard shorter intranasal mucosal atomization device (MAD Nasal Teleflex Medical, Inc, Morrisville, North Carolina) to directly spray nose upon removal of a face mask and followed immediately after by placing the NPFS around the patient. For those diagnostic laryngoscopies requiring more extensive topical anesthesia, including anesthesia of the larynx for view of the subglottis, we employed the technique as was a previously described, employing the MADgic Laryngo-tracheal mucosal atomization device through the anterior access port.\textsuperscript{15}
The diagnostic flexible trans-nasal laryngoscopies were performed with either a 2.6 mm Olympus ENF-V3 Video or 3.9 mm ENF-VH Olympus Rhinolaryngoscope during all patient encounters.

The transnasal laser and biopsy procedures were done with a flexible bronchoscope with a 4.2 mm outer diameter and a 2.0 mm working channel (BF-P190 slim bronchoscope. Olympus America. 3500 Corporate Parkway, Center Valley, Pennsylvania 18034-0610) (Figure 4). Biopsies were done with 1150 mm long disposable flexible biopsy forceps designed for use through a working channel no smaller than 2.0 mm (Endojaw Disposable Forceps Model No FB-231D. Olympus Medical Systems Corp. Tokyo, Japan).

In all 4 cases treated with laser laryngoscopy the patients were premedicated with a drying agent either by orally with 1 mg glycopyrrolate with sips of water 1 ½ hours preoperatively (3 patients) or with 0.2 mg glycopyrrolate IV 1 hour preoperatively (1 patient). 30 to 45 minutes before the procedure bilateral superior laryngeal nerve blocks were performed with 1 cc of 2% lidocaine with 1:100,000 epinephrine administered to each side (2 cc total) employing dental cartridges.17 Immediately before the procedure topical nasal decongestion and anesthesia was administered employing 4% lidocaine with 1% phenylephrine spray. Final topical anesthesia to the larynx was performed with delivery of ~2 cc of 4% lidocaine directly to the larynx through a 25-gauge sclerotherapy needle (Interject Sclerotherapy Needle Catheter 25 g × 240 cm Boston Scientific, Marlborough, Massachusetts) in the channel of the laryngoscope.

Mild sedation (1-2 mg of IV versed) was administered in two of the four operative cases as per the patients request with postoperative affirmation from both patients that they tolerated the procedure well and did not feel the sedation had been necessary.

As has been previously practiced, the transnasal laser laryngoscopy was done with KTP laser settings of 30 watts, 15 ms pulses, and 2 pulses per second for each case.18 Total dose delivered for the hemorrhagic polyp was 64 J employing in KTP V,1,2,3, and 4 modes according to the Mallur classification system19 (Supplement 2, Data S2—operative note; Supporting Information 1, Data S1—protocol). Treatment of the three patients with papilloma included a mixture of both contact and non-contact laser energy delivery with fluences of 58 J, 89 J, and 38 J.

During diagnostic laryngoscopy in clinic, pulse oximetry (Mallinckrodt N-20E Handheld Pulse Oximeter, Nellcor Puritan Bennett Inc, Pleasanton, California) was performed on each patient. This assessment was done prior to placement of the shield, during the procedure with the shield in place, and then following completion of the procedure after removal of the shield and replacement of their face mask.
During operative laser laryngoscopy monitoring of continuous pulse oximetry by anesthesia permitted review of recorded oxygen saturations pre, intra- and post procedure.

All patients responded to a 4-question survey performed at the conclusion of the procedure. Patients were asked to rate their tolerance of three factors: claustrophobia, shortness of breath, and pain. Responses were obtained on a 5-point Likert scale, with ratings defined as (1) none, (2) slight, (3) moderate, (4) severe, and (5) intolerable. The fourth question was an open-ended request for feedback on the experience, which was transcribed into the record and read-back for patient approval.

All study data were collected and managed using Research Electronic Data Capture (REDCap) tools hosted at the University of Iowa. REDCap is a secure, web-based software platform designed to support data capture for research studies, providing (a) an intuitive interface for validated data capture; (b) audit trails for tracking data manipulation and export procedures; (c) automated export procedures for seamless data downloads to common statistical packages; and (d) procedures for data integration and interoperability with external sources.

Overall tolerability was analyzed by dichotomizing the Likert scale such that values of (1) none or (2) slight were considered to be “well tolerated” and other values (3–5) were considered “not well tolerated”. This cutoff was determined a priori to define acceptable tolerance. The Clopper-Pearson procedure was used to construct confidence intervals for the true tolerability rate on each of the three factors. To compare tolerability between the two devices (NPFS v.3 vs NPFS v.4), a stricter tolerability threshold was applied such that only values of (1) were considered well tolerated, as preliminary data showed all subjects meeting the a priori threshold. Fisher’s exact test was used to determine if there were significant differences in the stricter tolerability proportion between groups.

### RESULTS

#### 3.1 Diagnostic laryngoscopy comparing NPFS version 3 and version 4

##### 3.1.1 Oxygen saturation

Descriptive statistics of oxygen saturation is presented prototype version, with the Version 3 group split by inclusion in the previously reported results and the distribution of values for the three groups (Table 1). Summaries for Version 4 remain unchanged. Model results...
show there is not a significant interaction between the two prototypes and time \(F[4, 269] = 0.99, P = .4129\), and there is also no significant main effect of prototype version \(F[2, 135] = 1.33, P = .2671\) or time \(F[2, 269] = 0.38, P = .6829\). This comparison indicates that oxygen saturation did not differ significantly between the two groups on Version 3 and Version 4 when measured pre-, intra-, or post-procedure (Figure 5). As there was not a significant interaction between version and time, differences between time points can be compared by averaging over the three groups. There were not any significant differences in oxygen saturation between any of the three time points (Table 2).

### 3.1.2 Patient tolerance

Assessment of tolerance on a 5-point Likert scale was assessed after the procedure. Ratings included (1) none, (2) slight, (3) moderate, (4) severe, (5) intolerable.

Observed tolerability and 95% confidence intervals for the proportion of subjects that would report the procedure as tolerable on each of the three factors identifies consistency in reported effect for the subgroups of subjects on Version 3 and 4 (Table 3). In the previously reported group of 30 subjects, 100% reported meeting the tolerability threshold on all three factors and with high confidence that the true tolerability rate is above 88% (Figure 6). In the subsequent subjects evaluated on Version 3, there was one subject reporting less than “well tolerated” claustrophobia (considered moderate claustrophobia—not severe or intolerable), with high confidence that the true tolerability rate for claustrophobia is above 93%. For shortness of breath and pain, all subjects reported these factors as well tolerated and we have high confidence that the true well tolerated rate is above 95% on these two factors. In comparing the stricter tolerability threshold (none vs any intolerance) between the three groups, the Fisher’s exact \(P\)-values were .4094, .2102, and .5484 for claustrophobia, shortness of breath, and pain, respectively. These results indicate no significant differences in the strict interpretation of “well tolerated” between the three groups.

### 3.1.3 Patient observations using NPFS v. 4 for diagnostic laryngoscopy

“not a big deal; it was all right; didn't bother me any more than the other way you did it.”

### Figure 4

The KTP laser is deployed through the NPFS within the channeled laryngoscope (see also 30 second video “laser laryngoscopy with NPFS” https://youtu.be/uCopwWqje_U). NPFS, negative pressure face shield.

### Table 1

Summary statistics of oxygen saturation during the NPFS procedures separating the previously reported version 3 group

| Time          | Version 3 Previously Reported (n = 30) | Version 3 Follow-up (n = 86) | Version 4 (n = 22) |
|---------------|----------------------------------------|------------------------------|---------------------|
|               | Mean   | Median | SD  | Mean   | Median | SD  | Mean   | Median | SD  |
| Pre-procedure | 97.83  | 98.00  | 1.48| 97.37  | 97.00  | 1.48| 97.91  | 98.00  | 1.38|
| Intra-procedure| 97.83  | 97.50  | 1.23| 97.52  | 98.00  | 1.53| 97.52  | 97.00  | 1.36|
| Post-procedure| 97.77  | 98.00  | 1.28| 97.49  | 98.00  | 1.44| 98.00  | 98.00  | 1.45|
I am claustrophobic, but I didn’t feel claustrophobic in there.

It was quick and easy, and I felt safe.

I can’t believe anybody would be claustrophobic in that.

Pretty neat; very safe; caught all that sneeze.

| Contrast             | Estimate | SE  | df  | t-ratio | P-value | Tukey adj P-value |
|----------------------|----------|-----|-----|---------|---------|------------------|
| Pre—Intra            | 0.0588   | 0.121| 269 | 0.49    | .3277   | .8782            |
| Pre—Post             | −0.0468  | 0.120| 269 | −0.39   | .6966   | .9195            |
| Intra—Post           | −0.1056  | 0.121| 269 | −0.87   | .3836   | .6580            |

**TABLE 3** Observed tolerance and 95% confidence intervals for the true tolerability rate

| Factor               | Version 3 (n = 116) | Version 4 (n = 22) |
|----------------------|----------------------|----------------------|
|                      | Tolerable (score ≤ 2) | Tolerable (score ≤ 2) |
|                      | n (%)                | n (%)                |
| Claustrophobia       | 115 (99.1%)          | 22 (100%)            |
| (95.29%, 99.98%)     | (84.56%, 100%)       |
| Shortness of Breath  | 116 (100%)           | 22 (100%)            |
| (96.97%, 100%)       | (84.56%, 100%)       |
| Pain                 | 116 (100%)           | 22 (100%)            |
| (96.97%, 100%)       | (84.56%, 100%)       |

“*I am claustrophobic, but I didn’t feel claustrophobic in there.*”

“It was quick and easy, and I felt safe.”

“I can’t believe anybody would be claustrophobic in that.”

“Pretty neat; very safe; caught all that sneeze.”

3.1.4 | Surgeon observations

The additional depth provided to the NPFS v.4 permitted use of the lower shelf to serve as a place for the patient to deposit the facial tissue given to them at the end of the case when they could blow their nose and clean their face in a closed environment (Supporting Information 2, Data S1—video and protocol). The inferior shelf was initially trialed for use as a chin rest. It was rapidly identified that complete immobilization of the head was not helpful. The flexibility in changing the orientation during the examination as afforded by head rotation and flexion with the chin immediately above and posterior to the lower flange was preferable. Additionally, keeping the nose and mouth more than 4 in. from the anterior wall and posterior to the suction port prevented moisture developing on the anterior pane (Supplement 3, Data S2).

3.2 | Operative experience with the NPFS v.4 for transnasal laryngoscopy with KTP laser and biopsy

The NPFS (v.4) was successfully used for laser laryngoscopy (with biopsy) for patients with laryngeal papilloma (3) and hemorrhagic polyp (1) with post-procedure questionnaire identifying no shortness of breath (4/4), no claustrophobia (4/4), no pain (4/4) and no significant changes in pulse oximetry during use.

A condensed 30 second video identifies the process of transnasal KTP laser and biopsy employing the NPFS v.4: (.mp4 video in
3.2.1 | Patient observations for operative (laser and biopsy) use of NPFS v. 4

“experience was fine, I was awake but had no worries about it.”

“It wasn’t as bad as I thought it was going to be worst part was pushing the probe through the nose, but that wasn’t bad either.”

“kind of like how you are better positioned; it was fine, no big deal; only negative was nose running.”

3.2.2 | Surgeon observations

Instrumentation through the anterior port in the NPFS v.4 was readily performed without additional difficulty compared to previous use in the pre-COVID era when done without the NPFS. The support provided to the flexible laryngoscope as it is passed through the anterior port offered further stability in performing the procedure.

4 | DISCUSSION

The COVID pandemic has stimulated development of novel strategies to limit spread of SARS-CoV-2 that are applicable to control of other surgically generated toxic and infectious aerosols. CDC-supported recommendation from the National Institute for Occupational Safety and Health (NIOSH) (accessed October 9, 2020) directs “a smoke evacuator or room suction hose nozzle inlet must be kept within 2 in. of the surgical site to effectively capture airborne contaminants generated by these surgical devices.” These NIOSH recommendations cite a single article (Smith et al24) in which CO2 laser plume dispersion was assessed leading to the additional assertion that if the smoke evacuation system were turned off for even a short period, high concentrations of fume would result that could lead to exposure. These investigators suggested that the suction must be functioning during the entire time the laser is in operation and ideally maintained on for an additional 20 to 30 seconds after the laser is turned off.

Our practice in limiting plume dispersion in the past had been to maintain suction on the channeled laryngoscope as much as possible during active lasing with hopes that process would decrease exposure of the laser plume not only to health care workers but also the patient. We continue this practice now supplemented by the additional control of the laser plume employing the NPFS.

Publications addressing flexible transnasal laser laryngoscopy in the pre-COVID era identify many excellent discussions about technical aspects of the procedure, but generally do not address suction control in detail. Prior to the COVID-era, reports were vague about limiting exposure to laser plume with general comments such as recommendations to use “proper smoke evacuation” and the more specific “after the procedure, surgeons kept on their masks for 10 minutes to clear the fumes from the surgical room.”

The importance of containing laser plume expands beyond that of limiting exposure to viral infection. Although the carcinogenic and cardiotoxic effects of laser plume remain theoretical in the absence of epidemiologic evidence, there is indirect evidence for the negative impact of environmental exposure to these substances. For example, a survey of nurses exposed to surgical plume identified respiratory conditions to be twice as prevalent among them when compared to the general population.
Protection from aerosol by mask wearing is established as a helpful health policy, but an incomplete method to limit exposure to viral spread. The misconception by many that surgical masks termed “laser masks” provided adequate protection has been modified in identifying that most toxic metabolites and viral particles are <5 μm and not adequately filtered by these masks.

Adaptations to the previously described NPFS v.3 permitted successful treatment of 4 patients with KTP laser. This operative use of the NPFS v. 4 was performed without additional difficulty and added confidence to the containment of aerosol.

Research addressing dissemination of laser combustion by-products has included a specific focus identifying infectious bioaerosol containing human papillomavirus (HPV). A “Triological Society Best Practices” review questioned the infectivity of laser plumes containing HPV but concluded that—unlike the less effective use of commercially available filters and masks—“evacuation of plume from the surgical field is likely an effective strategy to prevent viral contamination.”

Shortcomings to our study include the lack of data identifying successful containment of bioaerosol through use of the NPFS. Gaps in knowledge persist regarding inhalation exposure to papilloma viral particles and laser combustion by-products among surgical staff. Additional research is needed to evaluate the effectiveness of the NPFS v.4 at controlling exposure to virus aerosol particles generated during procedures. We are performing experiments to challenge the NPFS v.4 with aerosolized surrogate virus (eg, the bacteriophage MS-2) with preliminary favorable results. This work needs to be expanded into the operating room environment where the impact of both the surgical suite ventilation system and the NPFC v.4 can be assessed.

5 | CONCLUSION

The Negative Pressure Face Shield, initially designed to limit exposure to bioaerosols, was adapted with minor modifications to permit its application in efforts to contain laser plume during awake flexible transnasal laryngoscopy. Surgical procedures were readily accomplished with a high level of patient tolerance.

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CONFLICT OF INTEREST

Henry T. Hoffman: (a) COOK Medical: Research consultant and patent. (b) UpToDate: author. Co-authors Walsh, Pratt, Miller, Schwajle, Stegall, and Nonnenmann have no conflict of interest.

ORCID

Henry T. Hoffman https://orcid.org/0000-0003-4486-855X

REFERENCES

1. NSI Z136.3-2018: American National Standard for Safe Use of Lasers in Health Care. Washington, DC: American National Standards Institute; 2018
2. CDC NIOSH Control of Smoke for Laser/Electric Surgical Procedures DHHS (NIOSH) Publication Number 96-128; 1996. https://www.cdc.gov/niosh/docs/hazardcontrol/hc11.html. Downloaded October 6, 2020.
3. Pavan N, Crestani A, Abrate A, et al. Risk of virus contamination through surgical smoke during minimally invasive surgery; a systematic review of the literature on a neglected issue reviewed in the COVID-19 pandemic era. Eur Urol Focus. 2020;6(5):1058-1069. https://doi.org/10.1016/j.euf.2020.05.021.
4. Best SR, Esquivel D, Mellinger-Pilgrim R, Roden RBS, Pitman MJ. Infectivity of murine papillomavirus in the surgical byproducts of treated tail warts. Laryngoscope. 2020;130(3):712-717. https://doi.org/10.1002/lary.28026.
5. Born H, Ivey C. How should we safely handle surgical smoke? Laryngoscope. 2014;124(10):2213-2215. https://doi.org/10.1002/lary.24624.
6. DHHS (NIOSH). Publication Number 96-128. The National Institute for Occupational Safety and Health (NIOSH) Centers for Disease Control and Prevention “Control of Smoke for Laser/Electric Surgical Procedures”; 1996. https://www.cdc.gov/niosh/docs/hazardcontrol/hc11.html. Accessed October 9, 2020.
7. Searle T, Ali FR, Al-Niaimi F. Surgical plume in dermatology: an insidious and often overlooked hazard. Clin Exp Dermatol. 2020;45(7):841-847. https://doi.org/10.1111/ced.14350.
8. Serban D, Smarandache CG, Tudor C, Duta LN, Dascalu AM, Aliu C. Laparoscopic surgery in COVID-19 era-safety and ethical issues. Diagnostics (Basel). 2020;10(9):E673. https://doi.org/10.3390/diagnostics10090673.
9. U.S. Food and Drug Administration—FDA in Brief. https://www.fda.gov/news-events/fda-brief/fda-brief-fda-revokes-emergency-use-authorization-protective-barrier-enclosures-without-negative. Accessed October 3, 2020.
10. U.S. Food and Drug Administration—Letter to Manufacturers of Protective Barrier Enclosures. https://www.fda.gov/media/141415/download. Accessed October 3, 2020.
11. Simpson JP, Wong DN, Verco L, Carter R, Dzidowski M, Chan PY. Measurement of airborne particle exposure during simulated tracheal intubation using various proposed aerosol containment devices during the COVID-19 pandemic. Anaesthesia. 2020;75(12):1587–1595. https://doi.org/10.1111/ane.15188.
12. U.S. Food and Drug Administration—FDA letter to Healthcare Providers—Protective Barrier Enclosures Without Negative Pressure Used During the COVID-19 Pandemic May Increase Risk to Patients and Health Care Providers—Letter to Health Care Providers. Accessed October 4, 2020. https://www.fda.gov/medical-devices/letters-health-care-providers/protective-barrier-enclosures-without-negative-pressure-used-during-covid-19-pandemic-may-increase.
13. U.S. Food and Drug Administration—Fact Sheet for Healthcare Providers Emergency Use of the Airway Dome; 2020. FDA. https://www.fda.gov/media/140452/download. Downloaded October 4, 2020
14. U.S. Food and Drug Administration—Fact Sheet for Healthcare Providers Emergency Use of the Duke University COVIAGE; 2020. https://www.fda.gov/media/142450/download and https://www.fda.gov/media/142447/download. Downloaded October 4, 2020.
15. Hoffman HT, Miller RM, Walsh JE, Stegall HR, Diekema DJ. Negative pressure face shield for flexible laryngoscopy in the COVID-19 era.
16. Fink JB, Ehrmann S, Li J, et al. Reducing aerosol-related risk of transmission in the era of COVID-19: An interim guidance endorsed by the International Society of Aerosols in Medicine. J Aerosol Med Pulm Drug Deliv. 2020;33(6):300-304. https://doi.org/10.1089/jamp.2020.1615.

17. Hoffman HT (ed.). Iowa Head and Neck Protocols “Superior Laryngeal Nerve Blocks Instruction Video”. https://medicine.uiowa.edu/iowaprotocols/superior-laryngeal-nerve-blocks-instruction-video. Accessed November 15, 2020.

18. Hoffman HT (ed.). Iowa Head and Neck Protocols “Laryngeal papilloma (RRP) treatment in clinic with KTP laser video”. https://medicine.uiowa.edu/iowaprotocols/laryngeal-papilloma-rrp-treatment-clinic-ktp-laser-video. Accessed October 19, 2020.

19. Mallur PS, Johns MM, Amin MR, Rosen CA. Proposed classification system for reporting 532-nm pulsed potassium titanyl phosphate laser treatment effects on vocal fold lesions. Laryngoscope. 2014;124:1170-1175.

20. Harris PA, Taylor R, Thielke R, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377-381.

21. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009;42(2):377-381. https://doi.org/10.1016/j.jbi.2019.103208.

22. Baggish MS, Elbakry M. The effects of laser smoke on the lungs of rats. Am J Obstet Gynecol. 1987;156(5):1260-1265. https://doi.org/10.1016/0002-9378(87)90158-x.

23. Garden JM, O’Banion MK, Shelnitz LS, et al. Papillomavirus in the vapor of carbon dioxide laser-treated verrucae. JAMA. 1988;259(8):1199-1202.

24. Smith JP, Moss CE, Bryant CJ, Fleeger AK. Evaluation of a smoke evacuator used for laser surgery. Lasers Surg Med. 1989;9(3):276-281. https://doi.org/10.1002/lsm.190090311.

25. Tibbetts KM, Simpson CB. Office-based 532-nanometer pulsed potassium-titanyl-phosphate laser procedures in laryngology. Otolaryngol Clin North Am. 2019;52(3):537-557. https://doi.org/10.1016/j.otc.2019.02.011.

26. Wellenstein DJ, Honings J, Schimberg AS, et al. Office-based CO2 laser surgery for benign and premalignant laryngeal lesions. Laryngoscope. 2020;130(6):1503-1507. https://doi.org/10.1002/lary.28278.

27. Sanderson C. Surgical smoke. J Perioper Pract. 2012;22(4):122-128. https://doi.org/10.1177/175045891202200405 22567763.

28. Lyu W, Wehby GL. Community use of face masks and COVID-19: Evidence from a natural experiment of state mandates in the US. Health Aff (Millwood). 2020;39(8):1419-1425. https://doi.org/10.1377/hlthaff.2020.00818.

29. World Health Organization. Advice on the Use of Masks in the Context of COVID-19: Interim Guidance; 2020. Switzerland: World Health Organization. https://apps.who.int/iris/handle/10665/332293.

30. Chu, D.K., Akl, E.A., Duda, S., et al. COVID-19 Systematic Review Group Effort (SURGE) study authors. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. Lancet. 2020;395(10242):1973-1987. https://doi.org/10.1016/S0140-6736(20)31142-9. Accessed June 4, 2020.

31. Manson LT, Damrose EJ. Does exposure to laser plume place the surgeon at high risk for acquiring clinical human papillomavirus infection? Laryngoscope. 2013;123(6):1319-1320. https://doi.org/10.1002/lary.23642.

32. Neumann K, Cavalar M, Rody A, Friemert L, Beyer DA. Is surgical plume developing during routine LEEPs contaminated with high-risk HPV? A pilot series of experiments. Arch Gynecol Obstet. 2018;297(2):421-424. https://doi.org/10.1007/s00404-017-4615-2.

SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section at the end of this article.

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