

Laryngeal View During Laryngoscopy: A Randomized Trial Comparing Cricoid Pressure, Backward-Upward-Rightward Pressure, and Bimanual Laryngoscopy

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Study objective: External cricoid and thyroid cartilage manipulations are commonly taught to facilitate laryngeal view during intubation. We compare the laryngeal views during laryngoscopy with 4 manipulations (no manipulation, cricoid pressure, backward-upward-rightward pressure [BURP], and bimanual laryngoscopy) to determine the method that optimizes laryngeal view.

Methods: This was a randomized intervention study involving emergency physicians participating in airway training courses from December 2003 to November 2004. Direct laryngoscopies were performed with curved blades on fresh, non-fixed cadavers by using each of the 4 methods. The percentage of glottic opening (POGO), a validated scoring scale, was recorded for each laryngoscopy. Scores for bimanual laryngoscopy were recorded before the assistant applied external pressure.

Results: A total of 1,530 sets of comparative laryngoscopies were performed by 104 participants. One thousand one hundred eighteen of 1,530 sets (73%) had POGO scores less than 100 with no manipulation. Compared to no manipulation, mean POGO scores with bimanual laryngoscopy improved by 25 (95% confidence interval [CI] 23 to 27); mean POGO score improvement with cricoid pressure and BURP were 5 (95% CI 3 to 8) and 4 (95% CI 1 to 7), respectively. POGO scores with bimanual laryngoscopy were higher compared to cricoid pressure (mean difference 20, 95% CI 17 to 22) and BURP (mean difference 21, 95% CI 19 to 24). Among laryngoscopies with no manipulation in which the POGO score greater than 0 ($n=1,434$), laryngeal view worsened in 60 cases (4%, 95% CI 3% to 5%) with bimanual laryngoscopy, in 409 cases (29%, 95% CI 26% to 31%) with cricoid pressure, and in 504 cases (35%, 95% CI 33% to 38%) with BURP.

Conclusion: Using a cadaver model, we found pressing on the neck during curved blade laryngoscopy greatly affects laryngeal view. Overall, bimanual laryngoscopy improved the view compared to cricoid pressure, BURP, and no manipulation. Cricoid pressure and BURP frequently worsen laryngoscopy. These data suggest bimanual laryngoscopy should be considered when teaching emergency airway management. [Ann Emerg Med. 2006;47:548-555.]

0196-0644/\$-see front matter

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doi:10.1016/j.annemergmed.2006.01.013

INTRODUCTION

Background

Tracheal intubation by direct laryngoscopy is the primary means of airway management in cardiac resuscitation, emergency care, and general anesthesia. Laryngeal exposure is the main determinant of success or failure with this procedure.

The 3 commonly used techniques for manipulating the external anatomy to help improve laryngeal view are the Sellick maneuver (involving cricoid pressure), backward-upward-

rightward pressure (BURP, involving thyroid cartilage pressure), and bimanual laryngeal manipulation. Sellick¹ in 1961 described backward pressure on the cricoid cartilage as a method for preventing passive regurgitation of stomach contents and also facilitating endotracheal intubation. In 1993, Knill coined the term "BURP," describing the direction and pressure exerted on the thyroid cartilage by an assistant to improve laryngeal view at laryngoscopy.² Bimanual laryngoscopy involves operator-directed manipulation of the thyroid cartilage (Figure

Editor's Capsule Summary

What is already known on this topic

External soft tissue manipulation techniques are frequently used to improve the view of the airway before intubation. Previous studies have not directly compared these techniques and their impact on laryngeal view.

What question this study addressed

The authors examine the percentage of glottic opening visualized by 104 airway workshop participants performing 1,530 laryngoscopies in conjunction with a variety of soft tissue manipulation techniques, including cricoid pressure, backward-upward-rightward pressure (BURP), and bimanual laryngoscopy.

What this study adds to our knowledge

Specific manipulation techniques (bimanual laryngoscopy) may optimize visualization of the glottic opening, whereas other techniques (cricoid pressure, BURP) may worsen the view (in this study, 29% and 35%, respectively).

How this might change clinical practice

These data suggest bimanual laryngoscopy should be considered when performing and teaching emergency airway management.



Figure 1. A, Bimanual laryngoscopy showing the laryngoscopist applying thyroid cartilage pressure using the right hand. B, An assistant takes over so the laryngoscopist can place the tracheal tube.

1).^{3,4} Unlike cricoid pressure and BURP, both done by an assistant, bimanual laryngoscopy coordinates manipulation by the operator's right hand with simultaneous direct observation. After the view is optimized, laryngeal manipulation is then taken over by an assistant at that location, which frees the operator's right hand to place the tracheal tube.

Importance

Cricoid pressure and BURP are widely taught and now a standard aspect of resuscitation and airway training and are included in the American Heart Association's Advanced Cardiac Life Support materials, as well as numerous other reference texts in emergency care.⁵⁻⁷ Bimanual laryngoscopy has been previously shown to be a simple and effective method of improving the laryngeal view.⁸ However, no study has directly compared BURP and cricoid pressure with the bimanual laryngoscopy technique and evaluated their impact on laryngeal view.

Goals of This Investigation

The objective of this study was to compare laryngeal view percentage of glottic opening (POGO) scores obtained during direct laryngoscopy using no neck manipulation, cricoid pressure, BURP, and bimanual laryngoscopy on fresh non-fixed cadavers to determine the method that optimizes laryngeal view.

MATERIALS AND METHODS

Study Design, Setting, and Selection of Participants

This was a randomized intervention study that was conducted using 104 physician participants in emergency airway workshops from December 2003 to November 2004. The courses were taught for 2 days by the authors (R.M.L., W.J.L.) and included a detailed lecture series followed by a cadaver session in which the various techniques were performed.

Interventions

Participants were informed of the study objectives and all of the neck manipulation techniques had been discussed in the lecture component of the course. Each participant performed 4 comparative laryngoscopies (no manipulation, cricoid pressure, BURP, bimanual laryngoscopy) on each recently deceased cadaver obtained from the Maryland State Anatomy Board. Cadavers were not formalin fixed, but were arterially flushed with an isopropyl alcohol solution to preserve natural tissue turgor and prevent degradation, and were then refrigerated before each course. A total of 106 cadavers were used. All

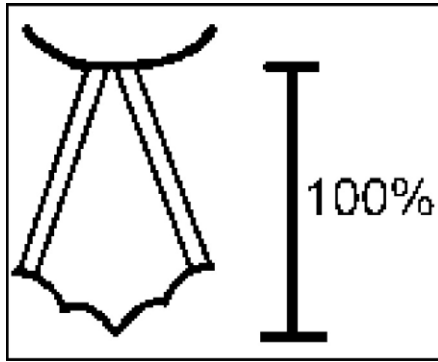


Figure 2. The POGO score represents the linear span extending from the anterior commissure to the interarytenoid notch of the vocal cords.^{8,42}

laryngoscopies were performed using curved blades. The order of laryngoscopies was randomly assigned for each participant.

Outcome Measures

Participants graded each laryngoscopy using the validated POGO score from 0% to 100%.^{9,10} Scores were reported to the nearest 1%. POGO scores have been shown to have excellent interrater reliability and very good intrarater reliability among airway providers of various experience levels.^{9,11} A POGO score of 100 denotes full visualization of the larynx from the interarytenoid notch to the anterior commissure of the vocal cords, and a POGO score of zero means none of the glottic opening is seen (Figure 2). POGO scores do not differentiate between epiglottis-only views and laryngoscopies in which the epiglottis is not visible. Participants had partners so an assistant could do cricoid pressure and BURP; bimanual laryngoscopy was done by the laryngoscopist with the right hand. Partners did not change during the comparative laryngoscopies. Each participant was asked to record his or her own POGO scores for each laryngoscopic view after performing each of the 4 maneuvers, therefore maintaining an internally consistent and independent scoring record. To assess the best laryngeal view possible, we defined a priori that the POGO score recorded during bimanual laryngoscopy would reflect the laryngeal view before the assistant assumed manual pressure from the laryngoscopist.

Primary Data Analysis

Results are presented as counts, percentages, means, or mean differences with 95% confidence intervals (CIs). An overall test of difference between groups was assessed using analysis of variance (ANOVA). Paired *t* tests were used for analysis comparing POGO scores between groups. Comparisons between groups were made using robust methods that adjust for the clustered nature of the data, with each laryngoscopist serving as a cluster (Stata svy commands).^{12,13} Fisher's exact test was used for comparisons of proportions. Data were analyzed using

Table. Training level of study laryngoscopists.

Participant Characteristics (N=104)	No. (%)
Practicing emergency medicine attending physicians	89 (86)
Emergency medicine residents (PGY 3 or PGY 4)	6 (6)
Non-emergency medicine practicing attending physicians	6 (6)
Paramedics	2 (2)
Physician assistants	1 (1)

PGY, Postgraduate year.

STATA software (version 7.0, Stata Corporation, College Station, TX).

Previous research has shown that a meaningful POGO score change of 25 is clinically significant.¹⁴ Assuming a detectable POGO score difference of 25, a 2-tailed α of 0.05, and a within-group standard deviation estimate of 25, a minimum power of 80% could be achieved with a per-group size of 27 intubation sets when adjusted for multiple-group comparisons. The size of the airway course made it feasible to accommodate a much larger sample size as an additional allowance for multiple comparisons.

The study was approved by the institutional review board at the University of Pennsylvania.

RESULTS

There were 1,530 sets of comparative laryngoscopies. The mean number of different cadavers (laryngoscopy sets) per participant was 15. The Table shows the experience levels of the participants. The POGO scores varied substantially between neck-manipulation groups when examined by ANOVA (all laryngoscopies: $F_{3,6116} = 121.4$, $P < .0001$; initial POGO scores < 100 : $F_{3,6116} = 121.4$, $P < .0001$). Figure 3 shows the POGO scores across all laryngoscopy maneuvers. Use of the bimanual laryngoscopy technique achieved higher POGO scores compared to no manipulation, BURP, and cricoid pressure; the higher POGO scores were maintained even when full glottic views were excluded (Figure 3B). Figure 4 shows the line plots for each neck manipulation as it changed from the initial no manipulation view.

In 1,118 of 1530 (73%) sets, laryngoscopy with no manipulation had POGO scores less than 100. POGO scores among this group with bimanual laryngoscopy improved by 25 (95% CI for the difference in mean 23 to 27) compared with no manipulation; the POGO score improvement with cricoid pressure was 5 (95% CI for the difference in mean 3 to 8) versus no manipulation; and the POGO score improvement with BURP was 4 (95% CI for the difference in mean 1 to 7) over no manipulation. Bimanual laryngoscopy provided a mean POGO score improvement of 21 (95% CI for the difference in mean 19 to 24) versus BURP and 20 (95% CI for the difference in mean 17 to 22) compared to cricoid pressure.

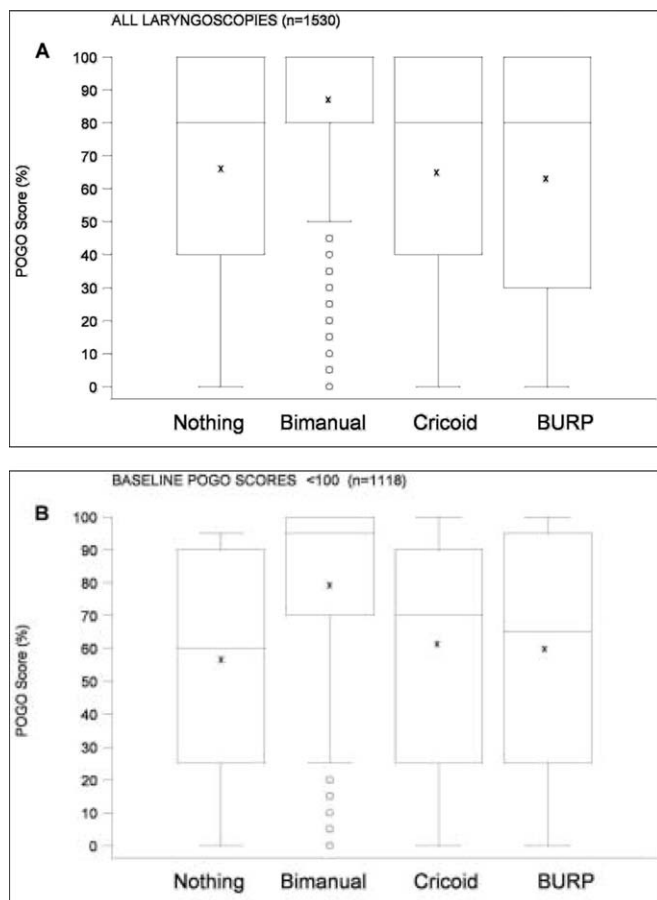


Figure 3. POGO by neck-manipulation group. Data are presented as box plots in which the X represents the mean and the horizontal box lines represent the 75th, 50th, and 25th percentiles. The stems represent the 90th and 10th percentiles. The circles indicate points beyond the 10th and 90th percentile. A, All laryngoscopies. B, Laryngoscopies with baseline POGO score (no neck manipulation) <100.

Among the same group of laryngeal views with initial POGO scores less than 100 with no manipulation, there was overall improvement in the laryngeal-view POGO score with bimanual laryngoscopy in 89% of cases (mean improvement 29, 95% CI 28 to 30). BURP improved the view in 54% of cases (mean improvement 26, 95% CI 24 to 27). Cricoid pressure improved the view in 52% of cases (mean improvement 25, 95% CI 23 to 26).

There were 96 laryngoscopies in which the POGO score equaled zero with no neck manipulation. In this subset, bimanual laryngoscopy provided a POGO score greater than 0 in 86% of cases, cricoid pressure 48% of cases, and BURP 51% of cases.

Compared to laryngoscopy performed with no manipulation, in which the POGO scores were greater than 0 and less than 100 (n=1,022), laryngeal view worsened in 110 cases with bimanual laryngoscopy (11%, with a mean POGO score

decrease of -7, 95% CI -9 to -4), in 490 cases with cricoid pressure (48%, mean POGO score decrease -17, 95% CI -19 to -15), and in 468 cases with BURP (46%, mean POGO score decrease -24, 95% CI -26 to -22) (Figure 5). Among this same group, the POGO score became zero (no portion of the glottis was visible) in 8 of 1,434 cases with bimanual laryngoscopy (0.5%, 95% CI 0% to 1%), in 46 cases with cricoid pressure (3%, 95% CI 2% to 4%), and in 94 cases with BURP (7%, 95% CI 5% to 8%).

LIMITATIONS

Our study should be interpreted with the following limitations. First, the use of a cadaver model is not a substitute for a live patient. However, we believe the cadaver model does approximate the mechanical feel and performance during laryngeal exposure of newly dead patients, such as in traumatic or cardiac arrest situations. Furthermore, it would be difficult to justify in anesthetized patients or cardiac arrest cases 4 randomly assigned laryngoscopies to investigate this subject. Second, we used the POGO score instead of endotracheal intubation success as the outcome. Direct laryngoscopy is a dynamic process, and by focusing on a key individual component, laryngeal exposure, we aimed to clarify a crucial element of the process. Third, our study did not investigate what happens to laryngeal view in the transition from bimanual laryngoscopy to intubation. After bimanual laryngoscopy is done, an assistant maintains neck manipulation to free the operator's right hand for placing the tracheal tube. In our experience, this procedure is not difficult but occasionally requires dynamic feedback from the laryngoscopist. We believe that reporting POGO scores before the handoff to an assistant represents the best achievable laryngeal view and is the best view for comparison. Fourth, although repeated laryngoscopy can cause tongue compression that may affect the subsequent ease of laryngoscopy, the use of a fresh-cadaver model and randomizing the order of laryngoscopy among participants minimized the problem. Finally, nonblinding of the laryngoscopist, given the technique of bimanual laryngoscopy, in addition to unmeasured factors, including measurement of the force of cricoid pressure and specific measurements of movement with BURP, makes it possible to have unaccounted confounding.

DISCUSSION

This study entailed a large number of emergency airway providers and a large number of laryngoscopies that compare laryngeal views with no manipulation, cricoid pressure, BURP, and bimanual laryngoscopy. Our results support the work of Benumof and Cooper³ and others who have concluded that optimal external laryngeal manipulation is done by the operator's right hand, with simultaneous observation of laryngoscopic view.^{4,15-18} Despite the fact that optimal external laryngeal manipulation, as described by Benumof and Cooper,³

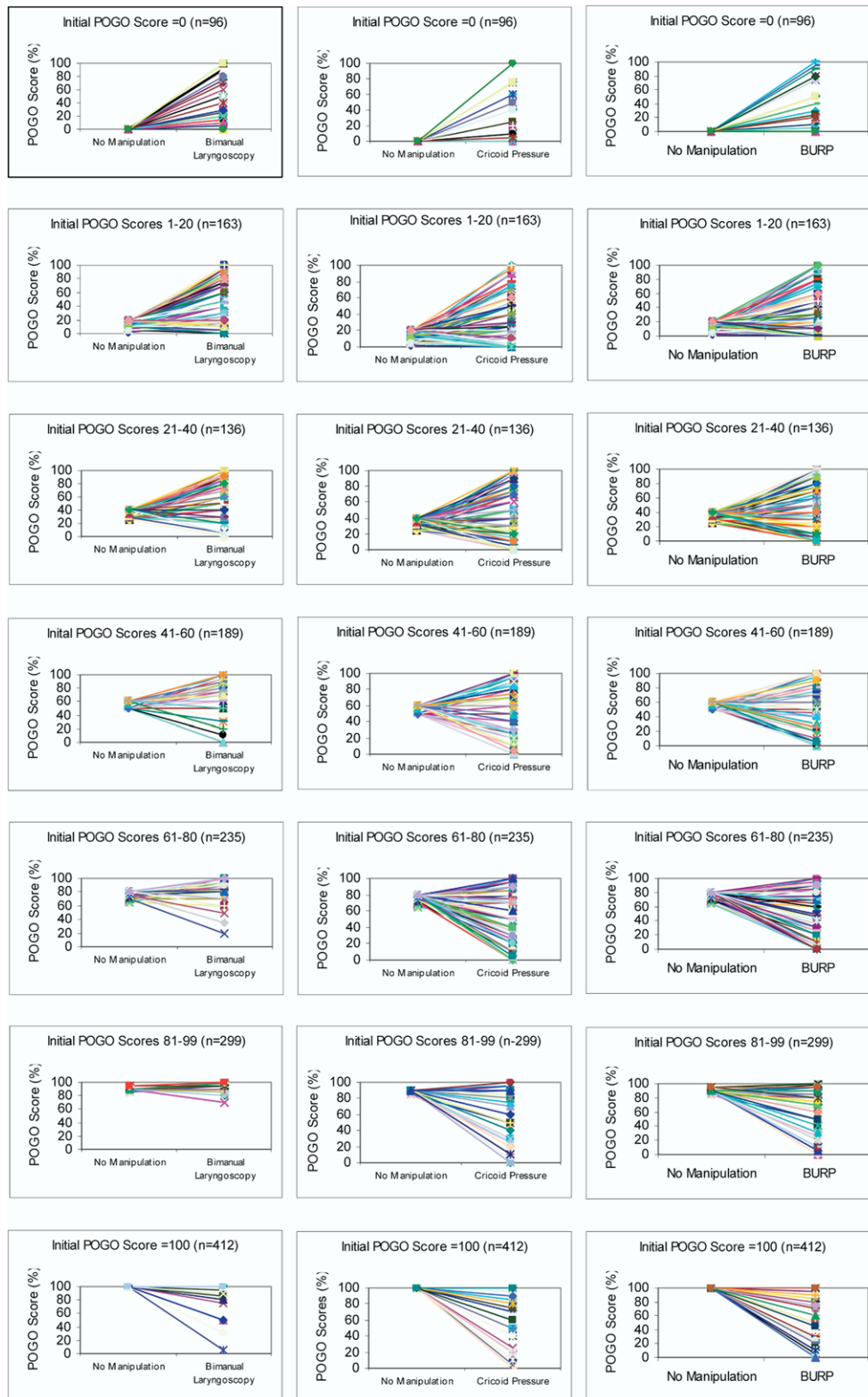


Figure 4. Line plots of POGO scores from laryngeal views comparing baseline no-manipulation views with the different neck-manipulation techniques. The plots are stratified by initial baseline POGO scores. The left column represents the bimanual laryngoscopy technique, the middle column cricoid pressure, and the right column BURP.

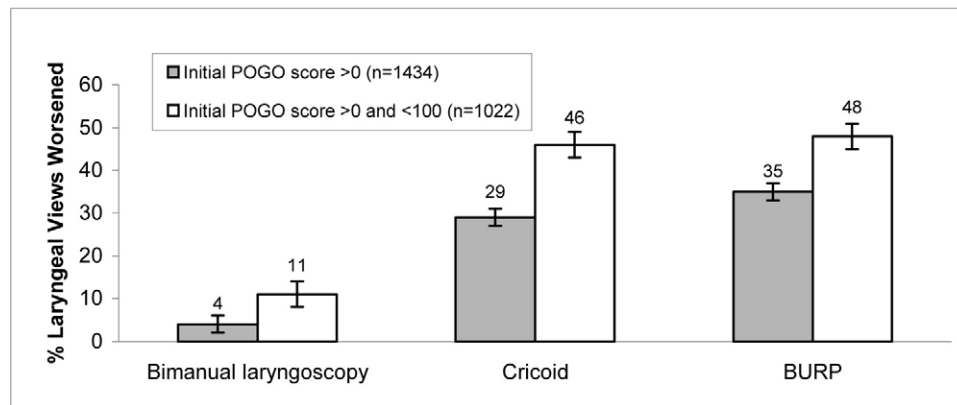


Figure 5. Percentage of laryngeal views that worsened by neck manipulation method. Vertical bars represent the 95% CIs around the estimates.

involves the thyroid cartilage in approximately 90% of cases, it is not equivalent to BURP, which involves an assistant manipulating the thyroid cartilage.²

Our study shows that bimanual laryngoscopy is more effective than both BURP and cricoid pressure at improving laryngeal exposure across the entire spectrum of glottic exposure. Additionally, compared to cricoid pressure and BURP, bimanual laryngoscopy was more effective at exposing the glottic opening if no portion of the glottis was visible without neck pressure and also improving exposure if the glottis was partially seen.

Direct laryngoscopy is a mechanical result of complex interactions between the laryngoscope blade, the anatomy of the patient, and forces applied by the operator or assistants. The mobility of the larynx and the beneficial effects of external laryngeal manipulation on laryngeal view were appreciated by the pioneers of indirect, or mirror, laryngoscopy even before direct laryngoscopy was described.¹⁵ Since the Kirstein¹⁶ report of straight-blade laryngoscopy in 1895, numerous authors have described that external pressure on the larynx improves laryngoscopic view.^{3,4,15,17–19}

Neck pressure applied during straight-blade laryngoscopy does not change the mechanics of epiglottis elevation because the epiglottis is elevated directly by the blade tip. In curved-blade laryngoscopy, however, the effect of neck pressure on laryngeal view and the mechanics of epiglottis elevation are much more complex. Curved blades indirectly elevate the epiglottis by pressure applied at the vallecula and underlying hyoepiglottic ligament. Subtle changes in the direction and amount of lifting force, as well as minor changes in the position of the blade tip, significantly influence how the blade fits in the vallecula and how well the epiglottis is elevated. Neck pressure becomes another variable within this complex mechanical interaction, and our results show that it often affects laryngeal view.

Although cricoid pressure has become standard practice, numerous studies have questioned its effectiveness for prevention of regurgitation and have highlighted the

detrimental effects on laryngoscopy and ventilation.^{20–28} Computed tomography and magnetic resonance imaging of the neck have undermined the simplistic concept that cricoid pressure causes esophageal occlusion (and can prevent regurgitation) because the esophagus is laterally displaced relative to the cricoid cartilage in approximately 50% of patients.^{29,30} The application of cricoid pressure itself causes esophageal displacement relative to the cricoid cartilage in more than 90% of patients.³⁰ Manometric evaluations have shown that cricoid pressure actually decreases lower esophageal sphincter tone, potentially increasing, not lessening, the risk of aspiration.^{31–33}

Previous studies assessing the impact of cricoid pressure on laryngeal view have reported conflicting results. Even authors who have reported cricoid pressure to have beneficial or neutral effects on laryngoscopy have emphasized that it has the potential to hamper laryngoscopy when performed with excessive force.^{34,35} Debate exists about what force is ideal, with recommendations ranging from 20 to 44 N.^{20,34,35} In a study by Turgeon et al,³⁵ cricoid pressure did not adversely affect laryngoscopic view or intubation success. The anesthesia assistants providing cricoid pressure practiced daily on simulators to consistently provide 30 N of force. Without use of force measurement devices, feedback trainers, or specially designed cricoid yokes, numerous studies of providers performing cricoid pressure have demonstrated poor compliance with proper technique.^{20,34–37} The current study, in which emergency physicians performed cricoid pressure without force measurements, is representative of what occurs in routine practice.

In addition to Knill's² original description of the BURP maneuver, which described 2 cases, only 2 English-language studies have prospectively studied the BURP technique. A 1997 study by Takahata et al³⁸ supporting its use was a single-center study involving 273 patients. The maneuver significantly improved laryngeal view, was more effective compared to simple backward pressure, and made some portion of the glottis visible in 12 patients who had initial epiglottis-only views. A second

study prospectively evaluated BURP, cricoid pressure, and no manipulation in 40 anesthetized surgical patients.³⁹ All patients had 3 randomly ordered laryngoscopies (no manipulation, cricoid pressure, and BURP) by the same operator, who was blinded to the maneuver performed by the assistant. Cricoid pressure alone worsened view in 12.5% of cases, whereas BURP worsened laryngoscopic view in 30% of cases.

Bimanual laryngoscopy, compared to an assistant pressing on the neck with cricoid or BURP, is also far less likely to compromise laryngeal view, a common occurrence in our study with cricoid pressure and BURP (29% and 35% of cases, respectively). The high incidence of view deterioration with BURP is similar to the 30% incidence reported by Snider et al.³⁹ We found a higher incidence of view deterioration with cricoid pressure than recorded by Snider et al³⁹ (29% versus 12.5%); however, we did not control for the amount of force applied, whereas Snider et al³⁹ limited cricoid pressure to 30 N.

Recent investigations of cardiac arrest management have pointed out the disparity between recommended guidelines and provider actual performance.⁴⁰ Given the complexities of properly applying cricoid pressure and BURP and how subtle changes in neck pressure can affect laryngeal view, we believe bimanual laryngoscopy has educational and logistic advantages in terms of simplicity and effectiveness. Avoidance of repeated laryngoscopy during emergency intubation is critical to avert hypoxia, regurgitation, bradycardia, and cardiac arrest.⁴¹ This study demonstrates that bimanual laryngoscopy optimizes the laryngeal view while under the operator's control in a cadaver model better than BURP or cricoid pressure.

The authors wish to thank Ronn Wade, AA, BS, and Anthony Pleasant, AA, from the Maryland State Anatomy Board for their assistance. Diane Kinkle and Ken Butler, DO, helped with data collection and the cadaver laboratory. Numerous residents from the Department of Emergency Medicine at the University of Pennsylvania also provided laboratory assistance. We also are saddened to report the death of one of the authors (Dr. William J. Levin) during the manuscript submission process.

Supervising editors: Kathy J. Rinnert, MD, MPH; Michael L. Callahan, MD

Author contributions: RML, WCK, and WJL conceived, designed, and collected data for this study. RML and WWE analyzed and interpreted the data. WWE provided statistical advice. RML drafted the manuscript, and all authors contributed substantially to its revisions and intellectual content. RML takes responsibility for the paper as a whole.

Dr. Levitan is now with the Department of Emergency Medicine, Albert Einstein Medical Center, Philadelphia, PA.

Funding and support: The authors report this study did not receive any outside funding or support.

Financial disclosures: Dr. Levitan is a principal owner of Airway Cam Technologies, Inc. (Wayne, PA). Practical Emergency Airway Management courses during the study were run by Airway Cam Technologies, Inc. and sponsored by the American Academy of Emergency Medicine.

Publication dates: Received for publication June 30, 2005. Revisions received October 3, 2005, and December 6, 2005. Accepted for publication January 3, 2006. Available online March 14, 2006.

Presented orally at the Society for Academic Emergency Medicine annual meeting, May 2005, New York, NY.

Reprints not available from the authors.

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