

Evaluation of Google Glass™ with Camera Adaptor and GoPro™ as Teaching Tools for Endotracheal Intubation in the Austere Medical Environment

Michael Son^{1,2}, David Zimmer^{3*}, Ross McCauley³, Donald Zimmer², Joseph Dynako³, Richard Skupski², Bhavesh Patel⁴, Nuha Zackariya⁵, Faadil Shariff⁵, Lovely Nathalie Colas⁶, Gerson Pyram⁶, Marc Edson Augustin⁶, Carmeline Mathurin⁶, Stanley Louis⁶, Patricia Saint Louis⁶, Stanley Loriston⁷, Dan Herbstman⁸, Lucio Cervantes⁹, Shane Kappler¹⁰, Michael T. McCurdy¹⁰, Jecko Thachil¹¹, Sarah Greve², Mark Walsh^{2,3,12}

¹University of Notre Dame, Notre Dame, IN, USA

²Memorial Hospital, South Bend, IN, USA

³Indiana University School of Medicine, South Bend, IN, USA

⁴Mayo Clinic, Phoenix, AZ, USA

⁵Indiana University Bloomington, Bloomington, IN, USA

⁶Hôpital Saint Luc, Port-Au-Prince, Haiti

⁷Department of Anesthesiology, Hôpital Universitaire Justinien, Cap Haïtien, Haiti

⁸Third Eye Health, Chicago, IL, USA

⁹Adisat Colonia: Condesa, Mexico City, Mexico

¹⁰University of Maryland School of Medicine, Baltimore, MD, USA

¹¹Department of Haematology, Manchester Royal Infirmary, Manchester, UK

¹²St Joseph Regional Medical Center, Mishawaka, IN, USA

Email: *dizimmer@iu.edu

How to cite this paper: Son, M., Zimmer, D., McCauley, R., Zimmer, D., Dynako, J., Skupski, R., Patel, B., Zackariya, N., Shariff, F., Colas, L.N., Pyram, G., Augustin, M.E., Mathurin, C., Louis, S., Louis, P.S., Loriston, S., Herbstman, D., Cervantes, L., Kappler, S., McCurdy, M.T., Thachil, J., Greve, S. and Walsh, M. (2018) Evaluation of Google Glass™ with Camera Adaptor and GoPro™ as Teaching Tools for Endotracheal Intubation in the Austere Medical Environment. *Open Journal of Anesthesiology*, 8, 229-239. <https://doi.org/10.4236/ojanes.2018.88024>

Received: July 11, 2018

Accepted: August 28, 2018

Published: August 31, 2018

Abstract

Objective: Endotracheal intubation (ETI) is a life-saving emergency procedure, but it is a complex skill that is difficult to teach. Recent studies have shown that video laryngoscopy is effective in teaching ETI to learners at various levels of medical expertise; however, it has proven to be costly and provides images of inconsistent quality. In this educational proof of concept feasibility convenience sample pilot study, we aim to explore and compare the effectiveness of using modified Google Glass™ (GG) and GoPro™ (GP) technologies to visualize and teach ETI to critical care physicians in the austere medical environment of a low-income country. We propose, based on our findings, that this inexpensive technology could teach lifesaving ETI to pre-hospital providers in the austere medical environment, medical students, rural emergency physicians, critical care physicians in low-income countries,

Copyright © 2018 by authors and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

far forward military medical providers, and other learners. **Methods:** A case series of twenty-five patients, five in the United States (US) at Memorial Hospital in South Bend, IN and twenty at Saint Luc's Hospital in Port Au Prince, Haiti, is presented. These patients were collected from November 1st 2015 through February 1st of 2016. The anesthesiologist and the emergency physicians in the United States utilized GG to intubate five patients in the US prior to the twenty patients intubated during two separate trips to Haiti. On the two separate trips to Haiti, the GG was trialed and modified to obtain better exposure. These adaptations resulted in the final collection of twenty patients studied with the adapted GG system and GP. Physicians graded airway visualization based on LEMON and Cormack-Lehane scores. Previously published parameters for the assessment of failed intubation risk and passage of the cords were used as data points for analysis using a Likert-Scale analysis for each parameter. The data were analyzed by averages of Likert-Scale scoring with their respective standard deviations. **Results:** The results show that the GP is superior to GG for assessing the LEMON scoring system until visualization of the oropharynx, while the GG is markedly superior for calculation of Cormack-Lehane score (cord visualization) and passing of the endotracheal tube. **Conclusion:** A review of the twenty-five cases demonstrates that while GP allows for better visualization for the parameters that require a wider view of the patient, the modified GG allows for superior visualization in the parameters that require a more focused view of the cords. GG can serve as an effective educational tool in the ICU for physicians and other providers in the austere medical environment who require effective ETI training. In addition, we propose that these techniques can serve as an inexpensive yet effective means of teaching hands on endotracheal intubation skills to learners of varying levels of clinical experience.

Keywords

Endotracheal Intubation, Google Glass™, GoPro™, Cord Visualization, Military Medicine, Austere Medical Environment, Low Income Country, Rural, Prehospital

1. Introduction

Recent literature has shown that video laryngoscopy performed by a number of methods can be useful for teaching endotracheal intubation (ETI) to learners at many levels of medical specialization [1]. However, these video laryngoscopes are expensive and provide images of an inconsistent quality [2]. Recently, an attempt was made to combine Glide Scope™ and iPhone™ to record ETI with learners. This involved a cumbersome mounting of the iPhone™ on the Glide Scope™ with an acceptable quality of the images [3]. Subsequent attempts have been made to use Google Glass™ (GG) to visualize and teach ETI among medical students and other learners [4] [5]. Not stated in the publications is that GG, when worn, does not allow visualization of the cords unless the learner stoops to

a position where there is direct line of sight between the eyes and the cords. This is due to the narrow field of view offered by GG. Likewise, the GoPro™ (GP), which has excellent resolution, does not allow reasonable visualization of the cords because of its wide and fish-eye (warped) field of view. This results in a distant view of the structures distal to the hypopharynx. The problem concerning line of sight with a narrow field of view that prohibits direct visualization of the cords is not cited in the literature regarding the utilization of GG as a teaching tool for ETI [4] [5]. In addition, the ability of GP to accurately visualize the cords has not been confirmed [6].

This is an educational proof of concept feasibility convenience sample pilot study to compare the ability of GG with Vuzix™ camera adaptor and GP-wearing anesthesiologists and emergency physicians from both Haiti and the United States, to use video recorded ETI for teaching purposes in the austere medical environment. In addition, we compare the connectivity of the two systems for live stream broadcasting. The video could be then used locally or remotely as an educational tool. The efficacy of each method is calculated using a five-point Likert Scale determined by the user regarding a checklist derived from preexisting literature concerning the basic markers for the preparation of ETI, cord visualization, and subsequent passage of the endotracheal cords.

Therefore, we have compared these two systems and describe the simple adaptation of the GG that allows for excellent visualization of the hypopharynx and the cords. We propose a system of the utilization of both the GG and GP to teach the basic steps of ETI.

2. Methods

A case series of twenty-five patients, five in the United States (US) at Memorial Hospital in South Bend, IN and twenty at Saint Luc's Hospital in Port Au Prince, Haiti, is presented. These patients were collected from November 1st 2015 through February 1st of 2016. The cohort studied was comprised of sixteen males and nine females ranging in age from eighteen to sixty years old. Institutional Review Board (IRB) approval was obtained and granted from the Memorial Hospital IRB. Informed consent was obtained for each patient. Consents were written in English and Creole and obtained by one of the authors who spoke Creole and English (DZ). In the US, the anesthesiologist and the emergency physicians utilized the GG to intubate five patients. This was the preliminary phase where the anesthesiologist and emergency physicians gained familiarity with the GG with and without various prototype adaptors (**Figure 1** and **Figure 2**). These five patients demonstrated the above-mentioned limitations of GG. Subsequently, adaptations were made based on two separate trips to Haiti which resulted in the final collection of twenty patients. The adapted GG system and GP allowed for the visualization of the vocal cords with varied success which were documented using the Likert-Scale assessment of the ETI parameters [7].

The group of physicians studied includes one US anesthesiologist, two US



Figure 1. Haitian anesthesiologist intubating mannequin with GG.



Figure 2. Haitian anesthesiologist intubating patient with GG.

emergency physicians, one Haitian anesthesiologist, and two Haitian critical care physician learners. The standard parameters for preparation and for monitoring successful ETI were the following: LEMON airway assessment method, the scissors maneuver, blade insertion, hypopharynx visualization Cormack-Lehane difficulty of intubation criteria, visualization of the cords and visualization of the endotracheal tube passing the vocal cords [8]. The LEMON scoring system is a mnemonic which stands for Look, Evaluate the 3-3-2 rule, Mallampati score, Obstruction, and Neck mobility [7]. The Cormack-Lehane system, based on grades 1 - 4 with 1 signifying full view of the glottis and 4 signifying neither glottis nor epiglottis seen, classifies the view seen by direct laryngoscopy based on the structures seen during endotracheal intubation [7]. The US anesthesiologist utilized the GP and GG while the two US emergency physicians only utilized GG. All three Haitian physicians utilized the GP and GG. Scoring and graphical

data reflect the Likert-Scale scoring system and not the scoring systems inherent in the original Cormack-Lehane classification.

3. Results

The results depicted in **Table 1** and **Figures 3-5** represent each physician and learner's best score during all attempts made during ETI with GP and GG. These results show that the GP is superior to GG for assessing the LEMON scoring system until visualization of the oropharynx. The GG is inferior for those previous parameters, but is markedly superior for calculation of Cormack-Lehane score (cord visualization) and passing of the endotracheal tube (**Figures 1-3**). This pattern is reflected whether in the US by an anesthesiologist teacher or in Haiti by US physicians or Haitian learners. The previous expertise in ETI by US emergency medicine physicians provided a significant advantage in vocal cord visualization and visualization of tube passing. Review of videos is easier on the GP because of the following reasons: 1) videos can be visualized on the GPs built-in screen, 2) the GP can transmit its own Wi-Fi signal allowing it to connect to larger mobile devices for real-time viewing. While the review of GG can

Table 1. Likert-Scale assessment of parameters for successful endotracheal intubation by US physicians and Haitian physicians.

User	US anesthesiologist 1	US anesthesiologist 1	US emergency physician 2	US emergency physician 3	Haiti anesthesiologist 1	Haiti anesthesiologist 1	Haitian learner 2	Haitian learner 2	Haitian learner 3	Haitian learner 3
Techniques evaluated	GoPro US 1	GG US 1	GG US 2	GG US 3	GoPro H1	GG H1	GoPro H2	GG H2	GoPro H3	GG H3
Look	5	4	3	3	5	3	5	3	4	3
Evaluate	5	4	3	3	5	3	4	3	3	3
Mallampati ≥ 3	5	4	3	3	5	3	2	3	3	2
Obstruction	4	3	2	2	3	3	2	2	3	2
Neck Mobility	5	3	3	2	5	3	4	3	3	3
Scissors	4	4	3	3	3	4	2	2	2	2
Blade Insertion	3	4	3	3	3	3	1	4	1	3
Teeth Avoidance	3	5	4	4	3	4	2	3	1	3
Hypopharynx Visualization	1	5	4	3	1	4	1	3	1	3
Cormack-Lehane $\geq 2a$	1	4	3	3	1	4	1	2	1	2
Tube Passing Cords	2	5	4	4	2	5	1	3	1	3
Mean Score	3.45	4.09	3.18	3	3.27	3.54	2.27	2.81	2.09	2.63

US 1—United States anesthesiologist, US 2 and US 3—United States emergency physicians, H1—Haitian anesthesiologist, H2 and H3—Haitian critical care physician learners.

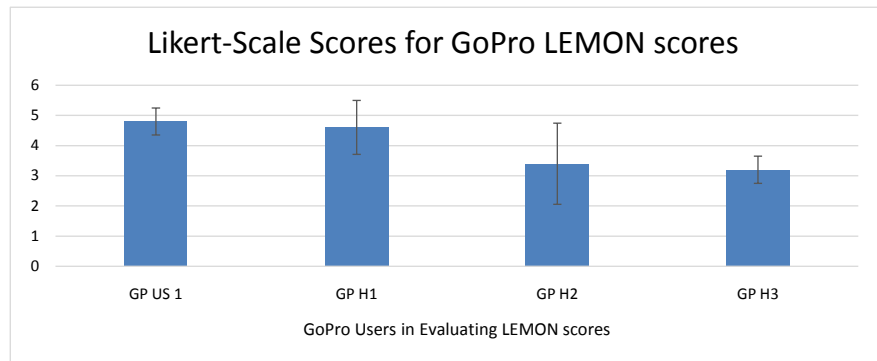


Figure 3. Likert-Scale scores for GoPro LEMON scores.

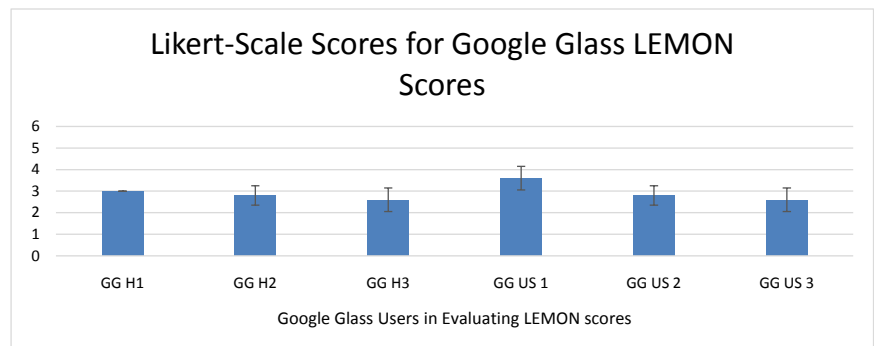


Figure 4. Likert-Scale scores for Google Glass LEMON scores.

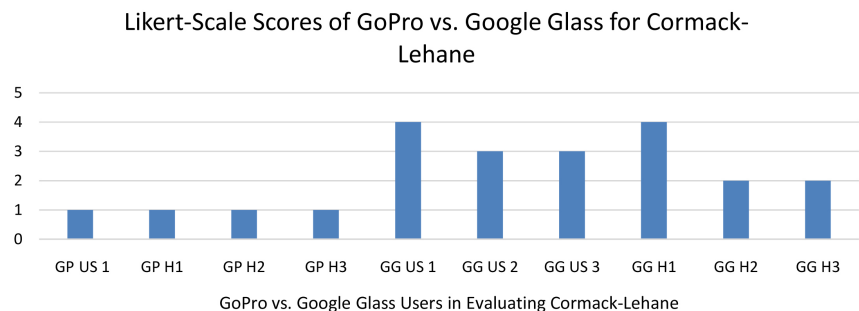


Figure 5. Likert-Scale scores of GoPro vs. Google Glass for Cormack-Lehane.

also be done in real time, it is made complicated by the need to remove and adjust headwear to the teacher's sight as well as its dependence on a wireless network rather than local connection. Both video files could be loaded on the portable computer and provided an educational opportunity with both methodologies for teacher and learner to evaluate the approaches for LEMON scoring. Visualization was unequal between GG and GP for the calculation of the Cormack-Lehane score. When viewed on a laptop, there were clear differences in the resolution of the GP vs. GG, with GP having much higher resolution capabilities with the tradeoff of decreased frame-rate and distant view of the cords due to its wide-angle fish eye lens. The GG was able to visualize the cords due to the zoom that was offered at the cost of narrower vision, reduced resolution but stable

frame-rate, while being unable to completely capture the intubators' field of view.

4. Discussion

Previous studies have demonstrated that telemedicine may be used for teaching critical care skills to physicians as well as non-physicians [9] [10]. Recently, telemedicine has been used to assist in the teaching of ETI and the monitoring of patients in the austere medical environment of low income countries [11].

This proof of concept feasibility study demonstrates that with further advancements in video quality, and adjustment of the GG scope, it would be possible to have video as well as real-time transmission of the entire process of ETI. Currently, GG when worn, does not allow visualization of the cords unless the learner stoops to a position where there is direct line of sight between the eyes and the cords (**Figure 6(a)**). However, the GG system, when modified so that the camera was placed below the eyes and above the superior labial margin, allowed for excellent visualization of the cords and passage of the endotracheal tube through the cords (**Figure 6(b)**, **Figure 7**, and **Figure 8**). Future use of telemedicine to transmit real-time images to a remote site has been described with the Glide-Scope™ and iPhone™ compatible visualization system [3]. This term, known as “Telebation” has been previously described, however its use required the highly technical and expensive Glide-Scope™ within a special adaptor. The technology reviewed here is portable and inexpensive. The advantages are that it can be used in the austere environment and allow for remote monitoring. GG can serve as an educational and consulting intervention in the ICU for physicians in the austere environment who can intubate as well as monitor ventilated patients in a setting where this would not be possible without on-site instruction. The use of this telemedicine technique was not available on either of our two



Figure 6. (a) Visualization of cords with GG camera at eye level; (b) Visualization of cords with GG between nose and upper lip.



Figure 7. Google Glass™ with extension.



Figure 8. Visualization of cords with Google Glass™ and camera adaptor.

trips due to lack of sufficient bandwidth. We plan future studies using the GG as a template for calculation of Cormack-Lehane scores and for documentation of passage of endotracheal tubes through cords. This will be dependent on our ability to fashion the previously mentioned adaptor to the headset that would allow simultaneous video recording as well as visualization of all phases of intubation. In addition, we hope to expand the bandwidth available at St. Luc's hospital such that we can trial remote video monitoring of ETI and, as such, apply the principles of "Telebation" previously mentioned [3].

Previous studies have presented either case reports or abstracts which describe in generic fashion the ability of GG to assist in teaching ETI, without describing the quality of visualization of the vocal cords or of the endotracheal tube passing the cords [4] [5] [12]. This is the first study of its kind to actually demonstrate in a quantitative fashion the ability of the GG to measure standard parameters of successful pre-intubation scoring, cord visualization, and endotracheal tube passage through the cords. A major technical limitation of GG is the narrow

field of view that requires that the learner establishes a direct line of sight while doing ETI. Therefore, the only way that the GG can be used to visualize the vocal cords is for the learner to crouch and to establish a line of sight that does not reflect the natural posture of the learner who is performing ETI (**Figure 6(a)**). We have described, for the first time, a very simple and rudimentary harness system that allows the wearer of GG to effectively assess all the parameters of successful intubation (**Figure 6(b)**, **Figure 7**, and **Figure 8**). Future ergonomic adaptations should allow for a much more robust study of using this very inexpensive tool as a teaching aid in the austere medical environment such as Haiti. **Table 2** and **Table 3** reveal the benefits and disadvantages of the GP and GG with lens adaptor for viewing ETI for the Haitian and US anesthesiologists. In addition, similar contrasts can be seen with US emergency physicians and Haitian critical care physician learners. In summary, the GP allows for better visualization for the parameters that require a wider view of the patient prior to visualization of the hypopharynx. However, the GG with adaptor allows superior visualization in the parameters that require more focused view of the cords (**Figure 8**).

5. Conclusion

This study has shown the feasibility of using the modified GP and GG technologies to instruct critical care physicians in ETI with the provision of excellent vocal cord visualization and accurate calculation of Cormack-Lehane scores.

Table 2. Advantages, disadvantages, and improvements for the Google Glass™ with adaptor.

Advantages of Google Glass™	Disadvantages of Google Glass™	Improvements needed for Google Glass™
Focused close-up shots	No retinal tracking (only moves with head, not eyes)	Retinal tracking
Potential streaming capabilities if connected to network	720p resolution	Higher resolution
Superior visualization of cords	<30 frames per second	Higher frame rate
	No universal mount (specific glasses)	Universal mount system & better ergonomics

Table 3. Advantages, disadvantages, and improvements for GoPro™.

Advantages of GoPro™	Disadvantages of GoPro™	Improvements needed for GoPro™
High resolution up to 4 k	Decreased frame-rate at higher resolutions	Need the ability to zoom
High frame rate capability up to 120 fps	Decreased resolution at higher frame-rate	Need to ability to correct fish-eye view pre-edit
Wide-angle shot increases field of view	Wide-angle shot decreases visibility of cords due to zoomed-out field of view	
Local WIFI connectivity	Limited WIFI range	

Multiple studies have revealed an increased need for hands on training and improved simulations for learners during their initial attempts at ETI, especially in the prehospital setting [13] [14]. We have proposed an inexpensive yet effective system utilizing GP and modified GG technologies which can be used to teach ETI to learners of any level of medical expertise. This wearable technology could be expanded to instruct ETI to prehospital personnel in austere environments, medical students, far forward military medical providers, and other learners in resource limited settings.

Acknowledgements

Manuscript was written and prepared by Michael Son BS, David Zimmer DVM, Ross McCauley MS, Joseph Dynako BS, NuhaZackariya, Faadil Shariff, and Mark Walsh MD. Editing was performed by Bhavesh Patel MD, Michael T. McCurdy MD, and Shane Kappler MD. Physicians performing intubation and adjusting equipment included Mark Walsh MD, Donald Zimmer MD, Richard Skupski MD, Lovely Nathalie Colas MD, Gerson Pyram MD, Marc Edson Augustin MD, Carmeline Mathurin MD, Stanley Louis MD, Patricia Saint Louis MD, Stanley Loriston MD, and Bhavesh Patel MD. Study idea and conception performed by Dan Herbstman BS, Mark Walsh MD, Donald Zimmer MD, Richard Skupski MD, Marc Edson Augustin MD, Bhavesh Patel MD, Lucio Cervantes BS, and Sarah Greve BS.

All authors reviewed and edited the paper.

Supported

This study was supported in part by an educational research grant by Third Eye Health and by the support of the family of Stefan Randjelovic.

Conflicts of Interest

Dan Herbstman is the CEO of Third Eye Health. The other authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Wei, N.J., Dougherty, B., Myers, A. and Badawy, S.M. (2018) Using Google Glass in Surgical Settings: Systematic Review. *JMIR mHealth and uHealth*, **6**, e54. <https://doi.org/10.2196/mhealth.9409>
- [2] O'Shea, J.E., Thio, M., Kamlin, C.O., *et al.* (2015) Videolaryngoscopy to Teach Neonatal Intubation: A Randomized Trial. *Pediatrics*, **136**, 912-919.
- [3] Mosier, J., Joseph, B. and Sakles, J.C. (2013) Telebation: Next-Generation Telemedicine in Remote Airway Management Using Current Wireless Technologies. *Telemedicine and e-Health*, **19**, 95-98. <https://doi.org/10.1089/tmj.2012.0093>
- [4] Kim, J., Craig, D., Dean, D., Schessler, B., Grider, S. and Brickman, K. (2015) 123 Video-Assisted Endotracheal Intubation via Direct Laryngoscopy Using Google Glass: A Pilot Study. *Annals of Emergency Medicine*, **66**, S43-S44. <https://doi.org/10.1016/j.annemergmed.2015.07.155>

- [5] Spencer, R.J., Chang, P.H., Guimaraes, A.R. and Firth, P.G. (2014) The Use of Google Glass for Airway Assessment and Management. *Pediatric Anesthesia*, **24**, 1009-1011. <https://doi.org/10.1111/pan.12496>
- [6] Kamath, A.M., Schwartz, A.J., Simpao, A.F., Lingappan, A.M., Rehman, M.A. and Galvez, J.A. (2015) Induction of General Anesthesia Is in the Eye of the Beholder—Objective Feedback through a Wearable Camera. The Accreditation Council for Graduate Medical Education Suite, Chicago, IL.
- [7] Reed, M., Dunn, M. and McKeown, D. (2005) Can an Airway Assessment Score Predict Difficulty at Intubation in the Emergency Department? *Emergency Medicine Journal*, **22**, 99-102. <https://doi.org/10.1136/emj.2003.008771>
- [8] Cormack, R. and Lehane, J. (1984) Difficult Tracheal Intubation in Obstetrics. *Anaesthesia*, **39**, 1105-1111. <https://doi.org/10.1111/j.1365-2044.1984.tb08932.x>
- [9] Levine, A.R., Buchner, J.A., Verceles, A.C., et al. (2016) Ultrasound Images Transmitted via FaceTime Are Non-Inferior to Images on the Ultrasound Machine. *Journal of Critical Care*, **33**, 51-55. <https://doi.org/10.1016/j.jcrc.2016.02.019>
- [10] Levine, A.R., McCurdy, M.T., Zubrow, M.T., Papali, A., Mallemat, H.A. and Verceles, A.C. (2015) Tele-Intensivists Can Instruct Non-Physicians to Acquire High-Quality Ultrasound Images. *Journal of Critical Care*, **30**, 871-875. <https://doi.org/10.1016/j.jcrc.2015.05.030>
- [11] Skupski, R., Toth, A., McCurdy, M., et al. (2018) Utilizing Anesthesiologists, Emergency and Critical Care Physicians with Telemedicine Monitoring to Develop Intubation and Ventilation Services in an Intensive Care Unit in the Austere Medical Environment: A Case Series. Expansion of the EP/CC GAS Project. *Open Journal of Anesthesiology*, **8**, 183-197. <https://doi.org/10.4236/ojanes.2018.86019>
- [12] Song, C., Choi, A., Roebuck, B. and Dannaway, D. (2017) Real-Time, Media-Enhanced Feedback Improves Neonatal Intubation Skills. *Journal of Investigative Medicine*, **142**, 234.
- [13] Warner, K.J., Carlbom, D., Cooke, C.R., Bulger, E.M., Copass, M.K. and Sharar, S.R. (2010) Paramedic Training for Proficient Prehospital Endotracheal Intubation. *Prehospital Emergency Care*, **14**, 103-108. <https://doi.org/10.3109/10903120903144858>
- [14] Katzenell, U., Lipsky, A.M., Abramovich, A., et al. (2013) Prehospital Intubation Success Rates among Israel Defense Forces Providers: Epidemiologic Analysis and Effect on Doctrine. *Journal of Trauma and Acute Care Surgery*, **75**, S178-S183. <https://doi.org/10.1097/TA.0b013e318299d650>