Intubation Efficiency and Perceived Ease of Use of Video Laryngoscopy vs Direct Laryngoscopy While Wearing HazMat PPE: A Preliminary High-fidelity Mannequin Study

Sara J. Aberle, MD;[1] Benjamin J. Sandefur, MD;[1] Kharmene L. Sunga, MD;[1] Ronna L. Campbell, MD, PhD;[1] Christine M. Lohse, MS;[2] Henrique Alecastro Puls;[1] Sarah Laudon;[1] Matthew D. Sztajnkrycer, MD, PhD[1]

1. Department of Emergency Medicine, Mayo Clinic, Rochester, Minnesota USA
2. Division of Biomedical Statistics and Informatics, Mayo Clinic, Rochester, Minnesota USA

Correspondence:
Matthew D. Sztajnkrycer, MD, PhD
Department of Emergency Medicine
Mayo Clinic GE-GR-G410
200 1st Street SW
Rochester, Minnesota 55905 USA
E-mail: sztajnkrycer.matthew@mayo.edu

Conflicts of interest: none

Keywords: direct laryngoscopy; hazardous materials; personal protective equipment; video laryngoscopy

Abbreviations:
BVM: bag valve mask
CBRNE: Chemical, Biological, Radiological, Nuclear, Explosive
DL: direct laryngoscopy
ED: emergency department
EMS: Emergency Medical Services
ETI: endotracheal intubation
HazMat: hazardous materials
LMA: laryngeal mask airway
PAPR: powered air-purifying respirator
PGY: post-graduate year
PPE: personal protective equipment
VL: video laryngoscopy

Received: January 1, 2015
Accepted: March 28, 2015

doi:10.1017/S1049023X15004707

Abstract

Introduction: Management of contaminated patients in the decontamination corridor requires the use of hazardous material (HazMat) personal protective equipment (PPE). Previous studies have demonstrated that HazMat PPE may increase the difficulty of airway management. This study compared the efficiency of video laryngoscopy (VL) with traditional direct laryngoscopy (DL) during endotracheal intubation (ETI) while wearing HazMat PPE.

Methods: Post-graduate year (PGY) 1-3 Emergency Medicine residents were randomized to VL or DL while wearing encapsulating PPE. Video laryngoscopy was performed using the GlideScope Cobalt AVL video laryngoscope. The primary outcome measure was time to successful ETI in a high-fidelity simulation mannequin. Three time points were utilized in the analysis: Time 0 (blade at lips), Time 1 (blade removed from lips after endotracheal tube placement), and Time 2 (bag valve mask [BVM] attached to endotracheal tube). Secondary outcome measures were perceived ease of use and feasibility of VL and DL ETI modalities.

Results: Twenty-one of 23 (91.3%) eligible residents participated. Mean time to ETI was 10.0 seconds (SD = 5.3 seconds) in the DL group and 7.8 seconds (SD = 3.0 seconds) in the VL group ($P = .081$). Mean times from blade insertion until BVM attachment were 17.4 seconds (SD = 6.0 seconds) and 15.6 seconds (SD = 4.6 seconds), respectively ($P = .30$). There were no unsuccessful intubation attempts. Seventeen out of 20 participants (85.0%) perceived VL to be easier to use when performing ETI in PPE. Twelve out of 20 participants (60%) perceived DL to be more feasible in an actual HazMat scenario.

Conclusion: The time to successful ETI was not significantly different between VL and DL. Video laryngoscopy had a greater perceived ease of use, but DL was perceived to be more feasible for use in actual HazMat situations. These findings suggest that both DL and VL are reasonable modalities for use in HazMat situations, and the choice of modality could be based on the clinical situation and provider experience.

Aberle SJ, Sandefur BJ, Sunga KL, Campbell RL, Lohse CM, Alecastro Puls H, Laudon S, Sztajnkrycer MD. Intubation efficiency and perceived ease of use of video laryngoscopy vs direct laryngoscopy while wearing HazMat PPE: a preliminary high-fidelity mannequin study. *Prehosp Disaster Med*. 2015;30(3):259-263.

Introduction

Historically, patient care "zones" in hazardous material (HazMat) events have been designated as hot, warm, and cold.[1,2] Minimal care is delivered in the hot zone, which represents the site of maximal and uncontained contamination. Rather, the objective in this zone is rapid extraction of the patient from the source of on-going exposure. The warm zone is a transitional area defined by a patient decontamination corridor. During the extraction and decontamination processes, HazMat-rated personal protective equipment (PPE) is worn. Warm zone care may occur in the field or in a hospital decontamination

facility. After decontamination is complete, the patient is transferred to the cold zone, an area in which no further contamination risk exists, and conventional patient care occurs.

Although traditionally patient care has been deferred according to the schema described above, unstable patients may require aggressive management in either the hot or warm zones. Failure to perform life-saving interventions is associated with an increased risk of avoidable death, frequently secondary to reversible respiratory failure following chemical agent exposure.[3,4]

By definition, any procedures occurring in the warm zone are performed by providers in HazMat PPE. Previous studies have demonstrated that PPE may increase the difficulty of airway management, even when using intubation aids or airway adjuncts.[5-8] In recent years, the use of video laryngoscopy (VL) has become more commonplace in emergency airway management.[9] The goal of the current study was to compare the efficiency by which an endotracheal tube could be placed properly by a patient care provider using VL or direct laryngoscopy (DL) while wearing HazMat PPE. A secondary goal was to assess provider perceptions of ease of use and feasibility with VL versus DL approaches to airway management while wearing HazMat PPE.

Methods

Study Population and Setting

The study population consisted of post-graduate year (PGY) 1-3 Emergency Medicine residents from a single residency program. The study was conducted while the residents participated in scheduled HazMat education and training in the use of PPE at a multi-disciplinary, high-fidelity simulation center. Inclusion criterion was consent to participate in the study. Exclusion criteria were refusal to consent, or presence of medical concerns precluding ability to participate, including pregnancy and claustrophobia. The study was reviewed and approved by the Mayo Foundation Institutional Review Board (Rochester, Minnesota USA).

Study Design

A randomized, crossover study with accompanying pre- and post-intervention questionnaires was conducted. Participants were de-identified and data were collected by pre-assigned numbers only. Prior to beginning the simulation center portion of the study, all participants were asked to complete a short questionnaire concerning previous experiences with different endotracheal intubation (ETI) techniques.

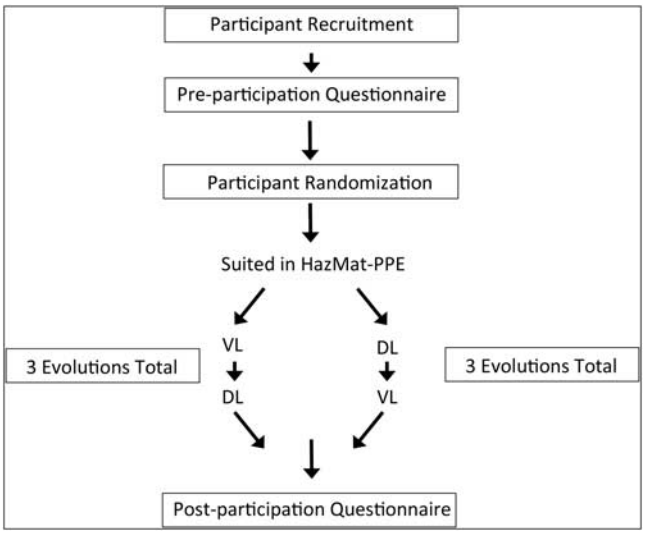
After completing the questionnaire, participants were randomized to VL or DL while wearing a Tychem F CPF 2 (DuPont USA; Wilmington, Delaware USA) encapsulating suit, Breathe Easy Butyl Hood System (3M Corporation; Maplewood, Minnesota USA) hooded powered air-purifying respirator (PAPR), nitrile gloves (Thermo Fisher Scientific; Waltham, Massachusetts USA), and Ongard Boots (Thermo Fisher Scientific) as PPE (Figure1). The primary intervention was the use of VL versus DL to perform ETI. Direct laryngoscopy was performed using standard fiberoptic laryngoscope blades (Heine USA LTD; Dover, New Hampshire USA) based upon the preference of the participant. Video laryngoscopy was performed using the GlideScope Cobalt AVL video laryngoscope (Verathon Inc; Bothell, Washington USA). Intubations were performed on a SimMan 3G (Laerdal Inc; Wappinger Falls, New York USA).

Having completed the initial VL or DL ETI procedure, as determined by randomization, participants then performed the remaining intubation method. Each participant completed a total of six alternating ETI procedures, three using VL and three using DL (Figure 2). Each participant served as his/her own control. The study sessions were recorded on video for ease of review and in a manner that allowed for de-identification of resident participants.

Upon completing the simulation portion of the study, each participant completed a post-intervention questionnaire regarding perceptions of ease of use and feasibility for each ETI modality while wearing PPE.

Aberle © 2015 Prehospital and Disaster Medicine

Figure 1. HazMat PPE Worn by Study Participants (see Methodology Section for Full Details about HazMat PPE Components).
Abbreviations: HazMat, hazardous materials; PPE, personal protective equipment.



Aberle © 2015 Prehospital and Disaster Medicine

Figure 2. Schematic of Study Randomization Protocol.
Abbreviations: DL, direct laryngoscopy; HazMat, hazardous materials; PPE, personal protective equipment; VL, video laryngoscopy.

https://doi.org/10.1017/S1049023X15004707 Published online by Cambridge University Press

Due to time and resource constraints of the HazMat education process and residency schedules, data were collected over four separate, yet standardized, simulation center sessions.

Outcome Measures

The primary outcome measure was time to successful endotracheal tube placement. Three time points were utilized in the analysis: Time 0 = blade at lips/insertion, Time 1 = blade removed from lips after endotracheal tube placement, and Time 2 = bag valve mask (BVM) attached to endotracheal tube. Successful endotracheal tube placement was confirmed using lung expansion monitoring of the high-fidelity simulation mannequin. The secondary outcome measures were perception of ease of use and feasibility of VL versus DL ETI modalities.

Data Collection

Simulation center video recordings were captured using liteCam HD (v5.0.0.2; Rsupport; Englewood Cliffs, New Jersey USA). Frame times were identified subsequently and recorded for Time 0, Time 1, and Time 2 using Apple iMovie software (v9.0.8; Apple Inc; Cupertino, California USA). De-identified participant data were entered into a Microsoft Excel Database (Microsoft Excel for Mac 2011, v14.4.3; Microsoft Corporation; Redmond, Washington USA). Data were correlated with questionnaire response data by use of pre-assigned participant numbers.

Statistical Analysis and Sample Size Calculations

Times were compared using either Wilcoxon signed rank or paired t-tests (SAS v 9.3; SAS Institute; Carey, North Carolina USA). When including the single outlier event, the three attempts per subject were averaged prior to analysis and *P* value calculated using Wilcoxon signed rank test. For analysis after exclusion of the single outlier, the two attempts (outlier excluded) or three attempts (remaining subjects) were averaged prior to analysis and *P* value calculated using a paired t-test. Fisher Exact Tests were used to compare resident survey responses. All tests were two-sided and *P* values $< .05$ were considered statistically significant. Continuous features were summarized with means and standard deviations. Categorical features were summarized with frequency counts and percentages. Statistical analyses were performed using the SAS software package (SAS Institute).

Sample size calculations were performed based on a two-sided paired t-test assuming 80% power and a significance level of .05. Assumptions for expected results were based upon the work of Shin et al.[10] The calculations indicated that a sample size of 17 would be required to power the study adequately to detect a difference of eight seconds between the two modalities. This assumed a mean time to success using one modality of 23 seconds and 15 seconds with the other modality with a pooled standard deviation of 10. If the standard deviation was 12, a sample size of 24 would have been required.

Results

Twenty-one of 23 (91.3%) eligible residents participated in the study; two residents were excluded due to medical concerns. One resident was excluded because she was an investigator in this study. By training year, seven PGY-1, eight PGY-2, and six PGY-3 residents participated (Table 1). Eleven (52.4%) residents reported more experience with VL than with DL on the pre-intervention questionnaire (Table 1).

PGY Level	More Experience VL	More Experience DL
Overall	11	10
PGY-1	2	5
PGY-2	6	2
PGY-3	3	3

Table 1. Summary of Participants by Post-graduate Year Level and Reported Intubation Experience with VL versus DL
Abbreviations: DL, direct laryngoscopy; PGY, post-graduate year; VL, video laryngoscopy.

Mean time to ETI was 10.0 seconds (SD = 5.3 seconds) in the DL group and 7.8 seconds (SD = 3.0 seconds) in the VL group ($P = .08$). The mean difference between the two groups was 2.2 seconds (SD = 6.0 seconds). Mean times from blade insertion until BVM attachment were 17.4 seconds (SD = 6.0 seconds) and 15.6 seconds (SD = 4.6 seconds), respectively ($P = .30$). A single participant required several attempts prior to successful ETI during one DL trial. The remainder of participants demonstrated first pass success during all attempts. After accounting for this single DL attempt outlier, the mean times to ETI (Time 1) and from blade insertion until BVM attachment (Time 2) were 9.4 seconds (SD = 3.5 seconds; $P = .08$) and 16.8 seconds (SD = 5.0 seconds; $P = .21$), respectively.

After completing the experimental protocol, 20 participants completed the post-study survey; 17 (85.0%) participants perceived VL to be the easier method when performing ETI while using PPE, including seven participants who reported more experience using DL ($P = .56$). In contrast, 12 (60.0%) participants felt that DL was more feasible during actual HazMat events, including eight participants who reported more experience with VL ($P = .36$).

Discussion

The need for patient decontamination due to HazMat exposure is a relatively uncommon occurrence in the emergency department (ED). Although specific numbers are difficult to determine, a study of HazMat events in Washington State (USA) found that 457 unique events occurred over a 5-year period, resulting in 2,654 victims.[11] Seventy percent of these patients were transported by Emergency Medical Services (EMS) to health care facilities. A hospital survey of HazMat preparedness reported management of an average of 2.4 chemically contaminated patients per year.[12]

Although ideally these patients would be decontaminated at the scene prior to transport, this does not always occur. In some cases, patients transport themselves directly to the hospital, bypassing the EMS response. This was noted after the nerve agent attack on the Tokyo (Japan) subway, in which ambulatory victims independently presented for medical care.[13] Even when transported by EMS, a 6-year study of HazMat events demonstrated that none of 72 patients presenting to the hospital received prehospital decontamination.[14] This lack of decontamination makes secondary contamination of hospital personnel an unfortunate reality.[15] In many circumstances, the exposure is irritating but not life threatening.[16] However, during the Tokyo subway incident, 11 of 15 medical staff on duty at a single ED developed symptoms consistent with nerve agent exposure, and six required

https://doi.org/10.1017/S1049023X15004707 Published online by Cambridge University Press

atropine therapy.[17] A study of hospital evacuations due to HazMat incidents identified 11 incidents, including two evacuations due to secondary contamination of ED staff.[18]

In order to address this potential threat, regulatory agencies have specified requirements for the emergent hospital-based management of chemically contaminated victims.[19,20] Amongst the emphasis for staff safety is appropriate selection of PPE for warm zone decontamination processes.[21,22] While PPE serves to protect the wearer from secondary contamination effects, it has the disadvantage of limiting dexterity and vision, thereby impairing the ability to perform medical interventions.[23-26] This intrinsic limitation is compounded by lack of familiarity with PPE operational posture. As a consequence, in the civilian sector, medical interventions are often deferred until the patient is decontaminated and brought from the decontamination area (warm zone) into the ED (cold zone).

A foreseeable consequence of this process of deferring care until the cold zone is reached is the potential for patient decompensation due to lack of timely life-saving interventions. Previous studies have noted this possibility, especially in terms of respiratory compromise.[3,4] Direct laryngoscopy in traditional HazMat PPE, including military style respirators, has proven challenging.[5] A prospective controlled study of anesthesiologists demonstrated an intubation time of 47.3 seconds (SD = 6.0 seconds) without PPE versus 69.2 seconds (SD = 7.0 seconds) with PPE. Quality of intubation view was described as very good in 6.25% while wearing PPE compared with 62.5% without PPE.[6] As a consequence, attention has turned to the use of airway adjuncts, and especially blindly inserted supraglottic airway devices.[27-29] A study of anesthetists versus non-anesthetists demonstrated that the mean time for ETI was 28.6 seconds, compared with 3.6 seconds for laryngeal mask airway (LMA) insertion ($P < .0001$).[28] Failed intubation while wearing chemical PPE occurred in 35% of anesthetists and 55% of non-anesthetists ($P = .17$). No failures were noted with LMA insertion.

While supraglottic devices appear to mitigate some of the effects of the PPE, they do not provide definitive airway management. Recently, VL has become a more readily available alternative to DL in establishing a definitive airway, even in austere medical settings.[30-35] A meta-analysis of VL versus DL for ETI demonstrated that use of VL was associated with improved airway visualization, particularly in patients with potential difficult airways and in non-expert performers.[9] The penetration of VL into the skill set of Emergency Medicine residents is such that 11 of 21 (52.4%) residents in this study reported more intubation experience with VL than with DL.

The improved visualization noted with VL may serve to mitigate the previously noted difficulties with airway visualization in PPE, allowing rapid establishment of a definitive airway. A study of 31 participants using the Pentax-AWS (Pentax; Hamburg, Germany) VL device demonstrated that although intubation times suited in PPE were longer than non-suited times, suited intubations using VL were faster than suited intubations using DL.[10] Interestingly, suited VL intubations were faster than non-suited DL.

The current study used the GlideScope (Verathon Inc) VL device, a commonly used system in North America. No significant difference was observed between times to ETI with DL and VL, as measured by time from first inserting the device until time of removal. Times to ETI were rapid in both groups with a mean difference between the two groups of only 2.2 seconds (SD = 6.0 seconds). Although the trend was towards statistical significance, the clinical significance is doubtful. Recent studies have suggested that the use of a hooded PAPR does not impair vision to the degree previously noted with military style Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) PPE.[36] This improved visualization ability might neutralize the noted benefits of VL.[9]

The rapidity of intubation (Time 1), even with DL, was unexpected. Intubation times were 17.4 seconds (SD = 6.0 seconds) for DL and 15.6 seconds (SD = 4.6 seconds) for VL from blade insertion until BVM attachment (Time 2). In the study by Ben-Abraham and Weinbroum,[29] intubation times in protective gear were 26.4 seconds (SD = 7.5 seconds) and 37.9 seconds (SD = 7.1 seconds) for anesthetists and non-anesthetists, respectively. However, that study defined the time period as the time from first grasping the laryngoscope until manual positive pressure was achieved. The current study measured the time from the blade first crossing the threshold of the lips until removal of the blade (Time 1), and until attachment of the BVM device to the endotracheal tube (Time 2). As such, compared with the study by Ben-Abraham and Weinbroum,[29] the current study was truncated at both ends of the intubation process. Time points were selected based upon the stated goal of determining speed and ease of intubation, and as such, attempted to remove unnecessary variables, including the time to grasp the blade and bring it into position and the time required to initiate the bagging process. These are both gross motor movement skills and are unlikely to be affected by PPE.

Seventeen (85%) of 20 participants who completed post-study surveys perceived that VL was easier to perform while in PPE than DL, including seven who reported more experience with DL. As such, in an unfamiliar clinical situation, such as patient care while wearing PPE, VL might increase operator comfort. Despite this, the majority of participants felt that DL was a more feasible airway management technique in a decontamination room environment. The rationale for this perception was not studied. Logistically, the use of an electrically powered device in an environment with large amounts of water might pose potential hazards to both patient and providers. Additionally, the technical decontamination of a VL device would be expected to be far more complex than that of a traditional DL device. In a worst-case scenario, the cost to discard and replace DL supplies would likely be considerably less than a VL device.

Limitations

This study has several important limitations. Twenty-one residents participated in the study. Although this represented 91.3% of possible participants, the power to detect a statistically significant difference between the two modalities was limited. Although an approximately two second difference between the two modalities in time to ETI was observed, the study was not powered adequately to detect statistical significance for this small of a difference. However, it is unlikely that a two second difference would be relevant clinically.

The participants were not blinded to airway device. They were also aware that they were being observed directly and recorded on video, potentially creating a Hawthorne effect. The net result might lead to subtle biases regarding the use of the airway devices.

The study involved a single high-fidelity simulation mannequin rather than actual patients. The mannequin did not have airway secretions or other clinical signs or symptoms likely present

https://doi.org/10.1017/S1049023X15004707 Published online by Cambridge University Press

in the setting of chemical agent exposure with airway compromise. The mannequin had consistent airway anatomy between participants and between individual attempts. Although airway mannequins have been used in other PPE studies, the Emergency Medicine residents who participated in this study had twice-quarterly simulation training using the same mannequin, and had familiarity with the airway anatomy.

This study used PAPR devices rather than military style CBRNE respirators for the airway protection component of PPE. In contrast to military style respirators, PAPRs have a greater field of view and are less likely to fog. Although many institutions use PAPRs as part of the PPE ensemble, both for ease of use and familiarity, the results of this study may not translate to other PPE ensembles.

Conclusions

In this preliminary study comparing intubation methods using a high-fidelity simulation model while wearing HazMat PPE, no statistically significant difference was found between time to successful ETI using VL or DL. These preliminary findings suggest that both DL and VL are reasonable modalities for use in HazMat situations, and the choice of modality could be based on the clinical situation and provider experience. Larger studies are needed to confirm or refute these findings.

References

1. Noll GG, Hildebrand MS. *Hazardous Materials: Managing the Incident*. 4th Edition. Burlington, Massachusetts USA: Jones and Bartlett Learning; 2014.
2. Kenar L, Karayulanoglu. Prehospital management and medical intervention after a chemical attack. *Emerg Med J*. 2004;21(1):84-88.
3. Baker DJ. Management of respiratory failure in toxic disasters. *Resuscitation*. 1999; 42(2):125-131.
4. Muskat PC. Mass casualty chemical exposure and implications for respiratory failure. *Respir Care*. 2008;53(1):58-63.
5. Flaishon R, Sotman A, Ben-Abraham R, Rudick V, Varssano D, Weinbroum AA. Anti-chemical protective gear prolongs time to successful airway management. *Anesthesiology*. 2004;100(2):260-266.
6. Hendler I, Nahtomi O, Segal E, Perel A, Wiener M, Meyerovitch J. The effect of full protective gear on intubation performance by hospital medical personnel. *Mil Med*. 2000;165(4):272-274.
7. Ben-Abraham R, Flaishon R, Sotman A, Ezri T, Weissenberg M, Weinbroum AA. Cuffed oropharyngeal airway (COPA) placement is delayed by wearing anti-chemical protective gear. *Emerg Med J*. 2008;25(12):847-850.
8. Castle N, Pillay Y, Spencer N. Comparison of six different intubation aids for use while wearing CBRN-PPE: a manikin study. *Resuscitation*. 2011;82(12):1548-1552.
9. Griesdale DEG, Liu D, McKinney J, Choi PT. GlideScope video-laryngoscopy versus direct laryngoscopy for endotracheal intubation: a systematic review and meta-analysis. *Can J Anesth*. 2012;59(1):41-52.
10. Shin DH, Choi PC, Na JU, Cho JH, Han SK. Utility of the Pentax-AWS in performing tracheal intubation while wearing chemical, biological, radiation, and nuclear protective equipment: a randomized crossover trial using a mannequin. *Emerg Med J*. 2013;30(7):527-531.
11. Burgess JL, Kovalchick DF, Harter L, Kyes KB, Lymp JF, Brodkin CA. Hazardous materials events: evaluation of transport to health care facility and evacuation decisions. *Am J Emerg Med*. 2001;19(2):99-105.
12. Cone DC, Davidson SJ. Hazmat preparedness: sufficient or so-so? [Abstract]. *Prehosp Disaster Med*. 1995;10(S3):S62.
13. Okumura T, Takasu N, Ishimatsu S, et al. Report on 640 victims of the Tokyo subway sarin attack. *Ann Emerg Med*. 1996;28(2):129-135.
14. Kirk MA, Cisek J, Rose SR. Emergency department response to hazardous materials incidents. *Emerg Med Clin North Am*. 1994;12(2):461-481.
15. Horton DK, Berkowitz Z, Kaye WE. Secondary contamination of ED personnel from hazardous materials events, 1995-2001. *Am J Emerg Med*. 2003;21(3):199-204.
16. Horton DK, Burgess P, Rossiter S, Kaye WE. Secondary contamination of emergency department personnel from o-Chlorobenzylidene Malononitrile exposure, 2002. *Ann Emerg Med*. 2005;45(6):655-658.
17. Nozaki H, Hori S, Shinozawa Y, et al. Secondary exposure of medical staff to sarin vapor in the emergency room. *Intensive Care Med*. 1995;21(12):1032-1035.
18. Burgess JL. Hospital evacuations due to hazardous materials incidents. *Emerg Med*. 1999;17(1):50-52.
19. Occupational Safety and Health Administration. *Hazardous Waste Operations Emergency Response*. Washington, DC USA: Occupational Safety and Health Administration; July 1, 2002. 29 CFR 1910.120.(c)(5).
20. Joint Commission on Accreditation of Healthcare Organizations. Guide to Emergency Management Planning in Health Care. Joint Commission Resources, Joint Commission on Accreditation of Healthcare Organizations: Oakbrook, Illinois USA; 2002.
21. Koenig KL, Boatright CJ, Hancock JA, et al. Health care facility-based decontamination of victims exposed to chemical, biological, and radiological materials. *Am J Emerg Med*. 2008;26(1):71-80.
22. Hick JL, Hanfling D, Burstein JL, Markham J, Macintyre AG, Barbera JA. Protective equipment for health care facility decontamination personnel: regulations, risks, and recommendations. *Ann Emerg Med*. 2003;42(3):370-380.
23. Castle N, Owen R, Hann M, Clark S, Reeves D, Gurney I. Impact of chemical, biological, radiation, and nuclear personal protective equipment on the performance of low- and high-dexterity airway and vascular access skills. *Resuscitation*. 2009;80(11): 1290-1295.
24. King JM, Frelin AJ. Impact of the chemical protective ensemble on the performance of basic medical tasks. *Mil Med*. 1984;149(9):496-501.
25. Coates MJ, Jundi AS, James MR. Chemical protective clothing: a study into the ability of staff to perform lifesaving procedures. *J Accid Emerg Med*. 2000;17(2): 115-118.
26. Berkenstadt H, Arad M, Nahtomi O, et al. The effect of a chemical protective ensemble on intravenous line insertion by emergency medical technicians. *Mil Med*. 1999;164(10):737-739.
27. Flaishon R, Sotman A, Friedman A, Ben-Abraham R, Rudick V, Weinbroum AA. Laryngeal mask airway insertion by anethetists and non-anesthetists wearing unconventional protective gear. *Anesthesiology*. 2004;100(2):267-273.
28. Goldik Z, Bornstein J, Eden A, Ben-Abraham R. Airway management by physicians wearing anti-chemical warfare gear: comparison between laryngeal mask airway and endotracheal intubation. *Europ J Anesthesiology*. 2002;19(3): 166-169.
29. Ben-Abraham R, Weinbroum AA. Laryngeal mask airway control versus endotracheal intubation by medical personnel wearing protective gear. *Am J Emerg Med*. 2004; 22(1):24-26.
30. Wayne MA, McDonnell M. Comparison of traditional versus video laryngoscopy in out-of-hospital tracheal intubation. *Prehosp Emerg Care*. 2010;14(2): 278-282.
31. Cooper RM, Pacey JA, Bishop MJ, McClusky SA. Early clinical experience with a new video laryngoscope (GlideScope) in 728 patients. *Can J Anaesth*. 2005;52(2): 191-198.
32. Su YC, Chen CC, Lee YK, Lee JY, Lin KJ. Comparison of video laryngoscopes with direct laryngoscopy for tracheal intubation: a meta-analysis of randomized trials. *Eur J Anaesthesiol*. 2011;28(11):788-795.
33. Kim YM, Kang HG, Kim JH, Chung HS, Yim HW, Jeong SH. Direct versus video laryngoscopic intubation by novice prehospital intubators with and without chest compressions: a pilot manikin study. *Prehosp Emerg Care*. 2011;15(1): 98-103.
34. Nakstad AR, Sandberg M. The GlideScope Ranger Video Laryngoscope can be useful in airway management of entrapped patients. *Acta Anaesthesiol Scand*. 2009;53(10): 1257-1261.
35. Nouruzi-Sedeh P, Schumann M, Groeben H. Laryngoscopy via Macintosh blade versus GlideScope: success rate and time for endotracheal intubation in untrained medical personnel. *Anesthesiology*. 2009;110(1):32-37.
36. Brinker A, Gray SA, Schumacher J. Influence of air-purifying respirators on the simulated first emergency response treatment of CBRN victims. *Resuscitation*. 2007; 74(2):310-316.