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Convergent Influence Effect on the High - Quality CPR of 119 Paramedics by Wearing Personal Protective Equipment by Level

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구급대원의 수준별 개인용 보호구 착용에 따른 심폐소생술 품질에 미치는 융합적인 영향

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Abstract The purpose of this study is to investigate the effect of wearing clothes, Level B, and Level C PPE on normal CPR using mannequins. The paramedics who participated in this experiment were 20 paramedics with more than 5 years of experience in firefighting area C. It was found that chest compressions in the process that hand off time was 11.9 seconds in the uniform wearing group, 11.4 seconds in the level C PPE wearing group, and 13.1 seconds in the SCBA wearing group. In other words, wearing personal protective equipment prevents the movement of paramedics and uses compensatory movements, which may increase the difficulty of efficient first aid. If this situation persists, it may cause fatigue and damage to the body of paramedics. Rescue and paramedics should wear level personal protective equipment in case of emergencies and conduct rescue and CPR training.

Key Words : Helmet, Personal protective equipment, Self-contained breathing apparatus, Cardio pulmonary resuscitation, Paramedics

요 약 본 연구에서는 마네킹을 이용해서 평상시 응급처치시 입는 옷, 레벨 B, 레벨 C PPE를 착용이 고품질의 심폐소생술에 미치는 영향을 알아보고자 한다. 본 실험에 참여한 응급구조사는 C 지역 소방 소속의 5년 이상의 경력을 가진 119 구급대원 20명을 대상으로 하였다. 심폐소생술 중 가슴압박이 중지되는 손이탈 시간 및 비율의 경우 유니폼 착용 그룹에서 11.9 초, 레벨 C PPE 착용 그룹에서 11.4 초, SCBA 착용 그룹에서 13.1 초인 것으로 밝혀졌다. 개인보호장비 착용은 구급대원의 움직임을 방해하고 있고 보상동작을 사용하게 되어 효율적인 응급처치의 어려움이 나타날 가능성이 많아지며, 이러한 상황이 지속될 경우 구급대원의 신체에도 피로감과 손상을 줄 수 있다. 구조 및 구급대원들은 응급상황을 대비해서 레벨별 개인보호장비를 착용하고 구조 및 심폐소생술 훈련에 임하여야 한다.

주제어 : 헬멧, 보호복, 공기호흡기, 심폐소생술, 응급구조사

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1. Introduction

Chemical, Bological, Radiological, Nuclear and Explosive(CBRNE) situations refer to disasters caused by chemical, biological, radiation, nuclear and explosives. Personal protective equipment(PPE) is essential to prevent secondary contamination when providing first aid and first aid to a patient in such a disaster. Therefore, emergency responders must select the appropriate PPE.

The Occupational Safety and Health Administration(OSHA)[1] says that emergency responders may use PPE in situations such as evolving disease, accidental industrial or commercial pollution, domestic and international terrorism, mass disasters and traffic accidents) to wear. Disasters sometimes appear in the form of CBRNE caused by explosions and trauma.

The most common protective clothing is protection levels A, B, C, and D as established by the OSHA. Paramedics need PPE to safely enter areas contaminated with HAZMAT to treat injuries. Level A is aimed at the maximum possible blocking and protection in the most severe stages of exposed hazardous substances. Along with positive pressure ventilated scuba (SCBA) equipment, these include capsule-type suits and gloves that block the body completely from the outside and block chemicals and vapors. Level B has a similar level of respiratory protection compared to level A, but protection against skin is a step down from level A. Level C is applicable when breathing is possible after the respiratory disease is blocked by purifying contaminated air through the air purifier and not by the scuba breathing. Level D is the minimum level of protection provided that there is no exposure to dangerous substances that can be damaged by respiratory or liquid ejection.

A recent study, on the other hand, suggests that personal protective equipment reduces crew movement and increases muscle sprains. Therefore, it has a negative effect on the performance of the activity[2-6]. Smith's study also found that PPE increases volume and weight, constraining members' activities and increasing physical strains[7]. In Korea, detailed procedures and actions, central guidelines and roles of the Central 119 Rescue Team are specified in the CBRNE Manual through the Terrorism and Accident Response Manual. Doing. In the event of a disaster, it is stated that protective clothing, respirators, non-penetrating gloves and boots should be worn by default. Paramedics working primarily in warm zones and cold zones should wear Class B or C protective clothing[8].

Since chest compressions become shallower between 1.5 and 3 minutes after CPR starts, alternating chest compressions every two minutes can help reduce rescuer fatigue and provide high quality CPR[9]. Several previous studies have evaluated the effects of PPE on airway management[10]. There is also little research on chest compression quality using PPE level C. However, few studies have performed high quality CPR on level B. The purpose of this study was to provide basic data on how to provide high quality CPR to patients after wearing normal clothes, Level B, and Level C using mannequins.

2. Research Method

2.1 Subject

The experiment was conducted at the 2nd floor simulation center of K University Health Center, C. The paramedics participated in this experiment were 20 119 paramedics with more than 5 years' experience in firefighting in C area. The subjects were selected as those who have practical experience in CPR and are in charge of first aid. All subjects agreed in writing after hearing the full explanation of the experiment. Subjects who did not wish to participate in the study were not included. Subjects selected the

number from the box containing the number, and after 1, they wore their usual clothes, 2, PPE C, and 3, SCBA after wearing CPR. I took a break (more than 3 hours each). Afterwards, the subjects who wore normal clothes wore PPE C, and those who wore PPE C wore SCBA, and those who wore SCBA performed CPR in the order of normal clothes. In this experiment, personal protective equipment (Tychem C, gas mask # 6800, 3M) corresponding to OSHA PPE level C was worn, and PPE level B was equipped with a self-contained breathing apparatus (SCBA). The experimental photograph is shown in Fig. 1.

(a) Paramedic Uniform CPR	(b) PPE level C CPR	(c) PPE level B(SCBA) CPR

Fig. 1. (a) (b) (c) PPE(Personal protective equipment) and CPR.

2.2 CPR

The experiment will begin with the investigator's start signal and subjects will receive 30 chest compressions and 2 chest compressions on the floor of a manikin (Resusci Anne QCPR®, Laerdal, Stavanger, Norway) set up to perform CPR for a cardiac arrest patient in a disaster situation. A 30: 2 one-man CPR procedure was performed. Previous studies [11,12] performed 30: 2 CPR for 5 minutes, but this study was performed for 4 minutes considering indoor environment and personal protective equipment.

Pulse check was not performed in the middle of CPR, and artificial respiration was performed using a bag-valve mask, considering that respiratory protective equipment cannot be used to orally ventilate with the patient. Positive pressure ventilation was performed.

Mannequins performed CPR using Laerdal's Resusci Anne QCPR®, a 'QCPR Instructor' app that monitors the feedback device mounted inside the mannequin in conjunction with the instructor's tablet device and stores the result in real time. The subject's name initials were stored in the app by date and time in a digitized record that includes chest compression rate, relaxation rate, average chest compression depth, speed, and adequate ventilation (using a pocket mask). In addition, the CPR sequence, location of chest compressions, and chest compression stop time were used by the investigator to evaluate the appropriateness or inadequacy.

2.3 Analysis of Research Data

SPSS 23.0 was used to evaluate the results of chest compressions and posture analysis of the paramedics according to the wearing of personal protective equipment during CPR. The results obtained are described as mean and standard deviation.

Since the normality of each measurement item was small in size, Shapiro-Wilk's normality test was conducted. The statistical significance level α was .05.

3. Research Results

3.1 General characteristics of the subject

The participants in this study were 20 male paramedics with a career of 97.55 ± 51.81 months, an average age of 33.35 ± 4.57 years, and a weight of 63.55 ± 11.41 kg. The results is shown in Table 1.

Table 1. General characteristics of the subjects (N=20)

Variables	Mean±SD
Age (years)	33.35± 4.57
Career (months)	97.55±51.81
Height (Cm)	176.45±6.43
Weight (kg)	63.55±11.41

3.2 Quality comparison of CPR

3.2.1 Quality of chest compressions

As a result, there was no difference in the relaxation depth of chest compression, and the average speed and the average depth were statistically different. However, there were statistical differences in the number of chest compression successes, hand off time, correct BVM use, and number of under ventilation.

The number of successful chest compressions was 272 in uniforms, 249 in Level C PPE, and 238 in SCBA. The group wearing the uniform had more successes and had a statistically significant difference compared with the group wearing the Level C PPE and the group wearing the SCBA ($p < 0.05$). There was no statistical difference between the group wearing Level C PPE and the group wearing SCBA. The quality of chest compressions results is shown in Table 2 and Fig. 2.

Table 2. The quality of CPR among three groups

Items	Uniform (MS±D)	Level C PPE (MS±D)	SCUBA (MS±D)	F	*P*
Compression success count	272.10 ±29.48	249.55 ±27.23	238.55 ±28.44	7.254	.002*
Compression Average rate(min)	116.29 ±11.20	111.18 ±10.76	102.94 ±9.67	8.133	.001*
Average Compression rate(min)	52.34 ±4.81	51.48 ±6.76	57.49 ±6.88	5.456	.007*
Average release depth (mm)	50.47 ±4.43	48.50 ±7.09	51.02 ±5.64	1.031	.363
hand off time	119.01 ±13.36	114.37 ±11.34	131.54 ±16.07	8.082	.001*
20 times BVM success count	14.55 ±2.54	12.65 ±2.52	9.95 ±3.00	14.698	.000*
Hypoventilation count	5.35 ±2.68	7.10 ±2.49	10.50 ±2.98	18.466	.000*

3.2.2 Hand off time

Hand off time was 11.9 seconds in the Uniform wearing group, 11.4 seconds in the Level C PPE wearing group, and 13.1 seconds in the SCBA wearing group. The group wearing SCBA showed longer hand off time and a statistically significant difference than the group wearing Uniform and the Level C PPE ($p < 0.05$). There was no statistically significant difference between the group wearing the uniform and the group wearing the Level C PPE. The hand off time result is shown in Table 2 and Fig. 3.

3.2.3 BVM Ventilation

Among the 20 BVM ventilations, the number of successes was 14.5 in the Uniform wearing group, 12.6 in the Level C PPE wearing group, and 9.9 in the SCBA wearing group.

The group wearing SCBA had fewer successful BVM ventilations than the group wearing Uniform and Level C PPE and showed a statistically significant difference ($p < 0.05$). There was no statistically significant difference between the group wearing the uniform and the group wearing the Level C PPE. 3>. The number of low ventilation was 14.5 in the uniform wearing group, 12.6 in the Level C PPE wearing group and 9.9 in the SCBA wearing group. The group wearing the SCBA had a higher number of low ventilation and a statistically significant difference compared with the group wearing the Uniform and the Level C PPE ($p < 0.05$). There was no statistically significant difference between the group wearing the uniform and the group wearing the Level C PPE. The BVM ventilation result is shown in Table 2 and Fig. 4.

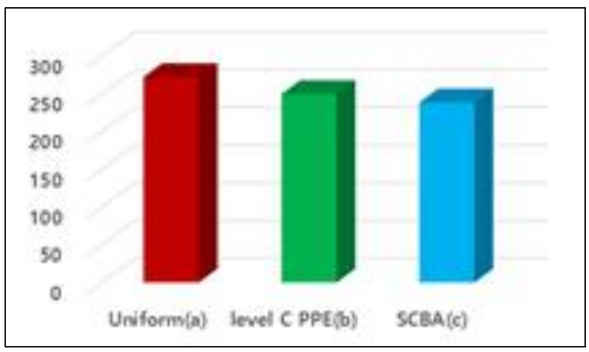

Fig. 2. Chest compression success count among three groups

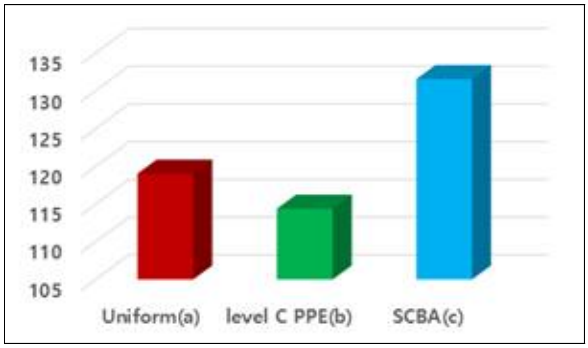

Fig. 3. Hand off time among three groups

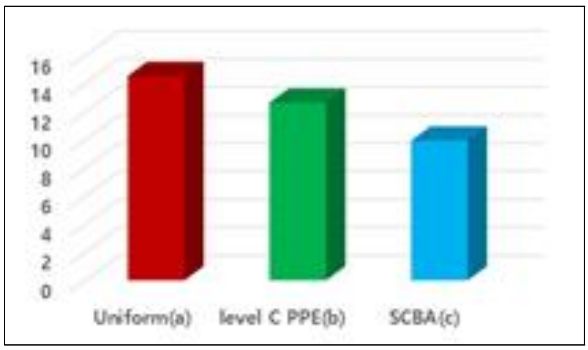

Fig. 4. Number of 20 successful BVM among three groups

4. Contemplation

In this study, there was no difference in the relaxation depth of chest compression, and there was a statistical difference in mean velocity and mean depth, but all three groups showed results that meet the AHA 2015 standard guidelines. There were statistical differences in the number of chest compression successes, hand off time, correct number of BVM use, and the number of under ventilation.

In a previous study, paramedics wearing personal protective clothing had worse results in the time and rate of hand release when breast compression was stopped when breast compression was performed. The mean cardiopulmonary resuscitation time was 11.1 seconds and 12.5 seconds in the non-wearing and wearing groups, respectively, longer than the wearing group ($p<0.05$), and the average difference between individuals was 1.3 seconds. Also, this result is consistent with the study that the quality of chest compression is improved through the stability of the core muscle[11].

This suggests that patients do not receive chest compressions for about 1.3 seconds per cycle when wearing CPR and this will increase with longer CPR. It also suggests that wearing personal protective clothing, including gloves, has a negative effect on chest compressions and may delay chest compressions and switching to ventilation techniques when performing CPR[12,13]. Ben-Abraham et al. Noted that CBRN protection makes injecting intravenous more difficult[5]. Punakallio et al. Reported that PPE increased fatigue[14]. Therefore, it is judged that the standardization and manufacture of PPE equipment in accordance with the standard body of Koreans can improve the problems.

The total hand departure time for 4 minutes increased from 107.00 ± 12.12 seconds without wearing personal protective equipment to 113.36 ± 14.32 seconds after wearing, and the average hand release time per cycle also increased from 11.13 ± 2.54 seconds to 12.55 ± 2.62 seconds The time to stop the pressure increased. These results suggest that wearing a protective glove on the hand did not make proper adjustment due to sensory changes in the hand. Coronary perfusion pressure decreases rapidly even during short chest compressions, which adversely affects the resuscitation of patients[15]. Therefore, it is important to wear gloves that can freely move hands during first aid. However, the average chest compression depth was 50.46 ± 5.98mm when the gloves were worn, but not statistically significant. This satisfies the minimum standard of 5cm, recommended by Field et al.[15] both before and after wearing personal protective equipment. These results suggest that paramedics were more consciously pressured to compensate for the slowing down of CPR caused by unfamiliar protective equipment. Therefore, if

training and education using personal protective equipment become habitual, it is considered that chest compression can be maintained while maintaining the depth of chest compression properly.

The most common protective suit is OSHA's typical protective suit as shown in Fig. 5. The SCBA consists of turnout coats, trousers, boots, gloves, breathing apparatus and helmets, and serves to protect paramedics from dangerous liquids, physical and electrical hazards as well as flames and high temperatures. The risk of death from apnea or cardiac arrest following a CBRN accident is very high[16]. Rapid treatment immediately after a CBRN accident can minimize the delay of death and maximize the chance of survival[10]. Decontamination after a CBRN accident takes at least 12 minutes per casualty, so emergency responders wearing CBRNs must wear personal protective equipment (PPE) and perform resuscitation procedures in warm areas (between contaminated areas)[17].

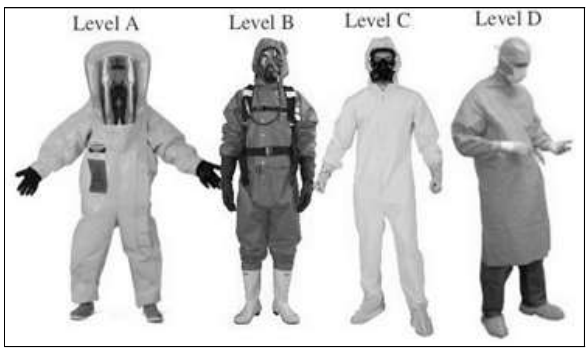

Fig. 5. Personal protective equipment by level

5. Conclusion

In the case of CPR, there was no difference in the index of chest compression in the group, but the worsening time and the rate at which chest compression was stopped showed worse results in the group wearing personal protective clothing.

In the case of paramedics wearing personal protective equipment, the positive pressure ventilation index decreased. This result shows that the bag-valve mask use is not properly made. Wearing personal protective equipment can disrupt the movement of paramedics and decrease the likelihood of efficient first aid, and if sustained, can cause fatigue and damage to the paramedic's body. Therefore, rescue and paramedics should wear personal protective equipment for each level in case of an emergency and perform rescue and CPR training.

6. Suggestions

In order to provide high quality CPR, two rescuer CPR should be performed rather than single rescuer CPR. Cooperation between rescuers is very important. Therefore, it is recommended that two or more rescuers collaborate in the basic resuscitation process with emphasis on how to provide high quality CPR.

In addition, for the protection of paramedics in a disaster situation, it should be possible to research and develop personal protective equipment suitable for reality.

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