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원 저

중환임상중독환자의 상황 인지와 대처 방법에 대한 시뮬레이션 교육의 효과 연구

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Implementing Best Practice in Critically Ill Organophosphate Poisoned Patient Through Simulation-Based Learning Program

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Purpose: Despite the clinical and socio-economic impact of acute poisoned patients, many of the treatments are not standardized in Korea. Moreover, no formal training that is specifically focused on clinical toxicology exists. Rather, training and education are conducted case by case in various institutions. This study was conducted to develop a standardized simulation-based clinical toxicology training curriculum for healthcare providers. This program will focus on specific assessment and treatment of critical toxicology patients, specifically those who have been poisoned with organophosphate.

Methods: The study was performed using a pre- and post-design to determine the effects of implementation of this program. The study was conducted at eight different urban teaching hospitals in a simulated room in the clinical area. The study was targeted to 19 groups composed of emergency residents and nurses. Simulation-based learning was conducted for each group.

Results: All 19 groups achieved the minimum passing score of 75%. Implementation of the program led to improved performance rates for overall management and cooperative moods competency (p<0.01). Inter-rater agreement between the two evaluators was excellent. In general, the participants thought the program was realistic and were able to recognize and improve the competencies needed to care for organophosphate poisoned patients.

Conclusion: Simulation-based learning is an effective educational strategy that can be applied to improving and understanding proper care for rare but critical patients. This program was effective at improving team performance and cooperative moods when managing an organophosphate poisoned patient in the Emergency Department.

Key Words: Simulation training, Organophosphate poisoning, Toxicology

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Introduction

According to the report in 2005 from the Center for Disease Control and Prevention in Korea, total of 836 patients admitted to the hospital for acute poisoning in the previous year[1]. The most common poisons involved were pesticides (45%) and prescribed medications (23%). The majority (64%) involved inten-

tional poisoning. The overall mortality rate was 8.7%. Pesticides and ages over 65 years old were strongly correlated with fatality[1].

Toxic overdose can present with various clinical symptoms, including abdominal pain, vomiting, tremor, altered mental status, seizures, cardiac dysrhythmias, and respiratory depression. These may be the only clues to diagnosis when the cause of toxicity is unknown at the time of initial assessment and management. The diagnosis may be complicated by the possibility of a multiple-drug ingestion. This variety of symptoms makes the healthcare providers difficult to provide optimal care[2-3].

The prognosis and clinical course of recovery of a patient poisoned by a specific agent depends largely on the quality of care delivered within the first few hours in the emergency setting. Fortunately, in most instances, the drug or toxin can be quickly identified by a careful history, a directed physical examination, and commonly available laboratory tests. Although only 3% of patients require critical care, survival discharge rate of resuscitated patients is lower than the non-drug induced cardiac arrest in Korea[4-5]. This implies that initial airway management and ventilator care is an important treatment strategy. Once the patient has been stabilized, the physician needs to consider how to minimize the bioavailability of toxin not yet absorbed, which antidotes to administer, and if other measures to enhance elimination are necessary. Out of the critical toxicology patients, organophosphate poisoning has become a rare clinical event in the urban area in Seoul. Depending on where the residents get trained and where the nurses work, clinical experience with organophosphate is very limited. Some institutions have never encountered any organophosphate poisoned patients in the last 3 years (Table 1). This means that certain resident in training who have never experienced an organophosphate poisoned patient will be board certified and taking care of patients in various institutions. Despite the clinical and socio-economic impact of acute poisoned patients, like the organophosphate poisoned patients, many of the treatments are not standardized in Korea[6]. On top of that, no formal training curriculum or courses exist specifically focused on clinical toxicology. Training and education are conducted case by case in various institutions.

Multifaceted training approaches, including experiential components with feedback and reinforcement, are more effective than didactics alone in producing lasting changes in healthcare practice[7-8]. Simulation is an educational method that could replace actual experiences, and have the students participate in an immersive and interactive manner. The objective of this project is to develop a standardized simulation-based clinical toxicology training curriculum for the

Table 1. Information of participated hospitals

	1	2	3	4	5	6	7	8	Average
Average number of ED patients during last three years	70,000	40,000	48,000	60,000	54,000	50,000	53,000	60,000	54,375
Average number of poisoned patients during last three years	98	200	444	300	1,000	245	561	165	376.6
Number of OPP									
2010	1	8	0	4	12	13	5	0	5.4
2011	1	6	18	3	8	14	1	0	6.4
2012	1	14	12	3	10	10	0	0	6.3
Number of OPP who admitted to ICU									
2010	1	8	0	4	3	4	0	0	2.5
2011	1	6	0	3	2	4	0	0	2.0
2012	1	14	7	3	3	5	0	0	4.1

ED: emergency department, OPP: organophosphate poisoned patients, ICU: intensive care unit

healthcare providers. This program will focus on specific assessment and treatment of critical toxicology patient presenting to ED, specifically organophosphate poisoned patient.

Methods

1. Study design and participants

This study was approved by the institutional review board of Yonsei University Severance Hospital and each participating hospitals. We developed a simulation-based learning (SBL) program on organophosphate poisoned patient care for emergency resident and nurses. The study was performed using a pre- and post-design to figure out the effects of implementation of this program on acceptance and performance rates of proper care. The study was explained to participants, and written consent was obtained from all subjects. Total of 74 participants (19 group) from 8 different hospitals were recruited for this study. Each group consisted of one junior resident (1-2 year in training), one senior resident (3-4 year in training), and two nurses with at least 2 years of experiences in the emergency department (ED). They were selected by convenience sampling and only those who consented to participate in the study were included.

2. Development of simulation-based learning program

Before the assessment, group of expert teams gathered and reviewed the current status of intoxicated patients admitting to the ED. The expert group consisted of emergency physicians and simulation training experts. Simulation training experts were selected from those who have attended formal faculty development training courses, and those with simulation training experiences of more than 3 years. The baseline survey and score sheets were revised and peer reviewed, and the scenario for the SBL intervention was developed. The validity of contents of questionnaire and assessment forms was verified by expert panel. The content validity index (CVI) consisted of '1 (0.25 points) not valid at all, 2 (0.5 points) not valid', 3 (0.75 points) valid', 4 (1.0 point) 'very valid'. To minimize bias and to be consistent with the study result, specific roles were designated to the participating researchers. One researcher was designated as the educator and debriefer, while another researcher was designated as the evaluator. A third person not involved in this study was designated as the second evaluator. After pilot testing to eight participants, the contents and evaluation tools were modified.

The participants grouped in four would enter a simulated ED setting, where a mannequin simulator, acting as patient is in need of emergency care. The "patient" is drowsy and showing various muscarinic symptoms (perspiration, urination, vomiting). The history information provided to the participants was limited. The "patient" was drunk and intentionally drank a bottle of unknown pesticide. The participants are supposed to recognize the symptom and signs of organophosphate poisoning, and proceed with proper care (universal precaution, decontamination, airway management, starting antidote). Each group was evaluated by a separate designated evaluator using a validated score checklist. The evaluation consisted of two parts: team performance and cooperative moods. Team performance evaluation included general and specific management of organophosphate poisoned patient. cooperative moods evaluation included leadership, communication, situation awareness, and capability to cope with emergency situation. All sessions were video recorded. After the simulation session, the designated educator sat with the participating group and conducted the debriefing session. After the debriefing session, a 30-minute didactic lecture was given on the topic organophosphate poisoning. The participants then entered the simulated ED setting again, and were asked to manage another simulated "patient" with similar symptoms and signs. Each group were evaluated by the same evaluator using the same score checklist. A third person was designated to evaluate each group's performances through recorded video sessions.

3. Data analysis

Checklist was validated through CVI. The researchers set a minimum passing score (MPS) using the modified Angoff method[9]. Reliability between the two evaluators were calculated. The second evaluator conducted the evaluation through video recorded performances. He was blinded to the timing of the assessing video, not knowing whether the viewing session was before or after the educational intervention. Nominal variables were calculated through kappa coefficient, while ordinal variables were calculated through intra-class coefficient method. Inter-observer reliability was calculated for each item of checklist. Each item of the checklist was grouped into similar categories. The purpose of grouping the checklist item was to assess the overall care competency and cooperative moods, rather than observing specific technical task. Cooperative moods assessment included a global assessment score as well. Pre- and post-intervention comparisons were made using Wilcoxon's signed ranks test. Values of $p<0.05$ were considered significant.

Results

The CVI was 0.88. The MPS was set at 75%. The participants consisted of 4 in each group, with a total of 19 group. All 74 participants or 19 group completed the study and no technical errors or difficulties were encountered during the study.

Table 1 describes the demographics of intoxicated patient admittance in the ED during the last three years. Average number of patients admitted to the ED was 54,375, regardless of the cause. The admittance rate for intoxicated patients was 0.68%, and the rate for organophosphate poisoned patients was 1.59%. The admitting numbers varied between hospi-

Table 2. Baseline demographic data

Character		Residents	Nurses
Mean age (year)		30.00±3.75	28.80±4.53
Male		36 (94.73)	6 (16.67)
Female		2 (5.26)	30 (83.33)
Number of years working in ED			
For residents	For nurses		
1	<1	14 (36.8)	1 (2.8)
2	1~3	10 (26.3)	22 (61.1)
3	4~6	10 (26.3)	8 (22.2)
4	6~10	4 (10.5)	5 (13.9)
Number of experience in treating with poisoned patients per year		6.09±10.54	3.33±5.00
Number of experience in treating with OPP		4.46±6.80	2.28±2.94
0		7	12
1~3		20	18
4~9		5	3
≥10		6	3
Confidence in treatment with OPP (in scale one to ten)		4.82±2.29	5.19±2.00
Education type for organophosphate poisoning			
Lecture only		8 (21.1)	9 (25)
Practice only		0 (0)	1 (2.8)
Lecture with practice		2 (5.3)	1 (2.8)
Bedside teaching		25 (55.3)	9 (25.0)
None		3 (7.9)	16 (44.4)
Experience of simulation education			
Yes		16 (42.1)	20 (55.6)
No		22 (57.9)	16 (44.4)

ED: emergency department, OPP: organophosphate poisoned patients

tals. We could observe that healthcare providers in the ED experience very limited number of organophosphate poisoned patient.

Table 2 demonstrates the general characteristics of 74 participants of this study. Most participants had none or very limited experience with organophosphate poisoned patients. Most of the education was conducted either through bedside teaching or class-

Table 3. Overall result of education

		Median	95% CI for median	*p* value
Team performance	Before	8/20	7.00-8.22	<0.0001
	After	18/20	16.00-19.00	
Cooperative mood	Before	6/10	5.78-6.0	<0.0001
	After	8/10	8.00-9.00	

CI: confidence interval

Table 4. Checklist results for team performance

	Before	After	κ	*p* value
Pollutant precaution				
Universal precaution	0/19 (0)	11/19 (57.9)	0.82	
Patients was completely undressed	3/19 (16)	19/19 (100)	1.00	
Patient's clothing was handled as pollutant material	0/19 (0)	16/19 (84.2)	0.95	
Wash the pollutant that stained on patient's body	0/19 (0)	13/19 (68.4)	0.82	
Overall estimation for performing precaution	3/76 (3.9)	59/76 (77.6)	0.90	<0.001
Initial assessment				
Attached monitoring device to the patient	19/19 (100)	19/19 (100)	1.00	
Check patient's mental state	19/19 (100)	19/19 (100)	1.00	
Check pupil size & reflex	19/19 (100)	18/19 (94.7)	0.62	
Overall estimation for performing initial assessment	57/57 (100)	56/57 (98.2)	0.87	0.317
Airway management				
Oxygen supply	11/19 (57.9)	19/19 (100)	0.75	
Oral suction	10/19 (52.6)	18/19 (94.7)	0.71	
Intubation	17/19 (89.5)	19/19 (100)	0.66	
Overall estimation for airway management	38/57 (66.7)	56/57 (98.2)	0.71	0.001
Intubating medication				
Appropriate sedative agent	11/19 (57.9)	19/19 (100)	0.57	
Appropriate NM blocking agent	10/19 (52.6)	18/19 (94.7)	0.79	
Overall estimation for selecting adequate medication	21/38 (55.2)	37/38 (97.4)	0.68	0.005
Circulation				
Insert peripheral IV catheter.	19/19 (100)	19/19 (100)	1.00	
Fluid loading	8/19 (42.1)	19/19 (100)	0.49	
Overall estimation for maintaining circulation	27/38 (71.1)	38/38 (100)	0.74	0.01
Laboratory test				
Prescript serum cholinesterase or pseudocholinesterase	2/19 (10.5)	6/19 (31.6)	0.83	0.125
Antidote				
Administer atropine	3/19 (15.8)	19/19 (100)	1.00	
Administer pralidoxime	2/19 (10.5)	19/19 (100)	0.95	
Overall estimation for administration of antidote	5/38 (13.1)	38/38 (100)	0.97	<0.001
Decontamination				
Consider indication of gastric lavage	1/19 (5.36)	17/19 (89.5)	0.84	
Consider indication of activated charcoal	1/19 (5.36)	17/19 (89.5)	0.95	
Consider indication of hemodialysis	2/19 (10.5)	17/19 (89.5)	0.95	
Overall estimation for performing decontamination	4/57 (7.02)	51/57 (89.5)	0.91	<0.001

NM: neuromuscular, IV: intravenous

Table 5. Checklist results for cooperative moods

	Before	After	κ	*p* value
Leadership				
Leader shared overall information with the team member	5/19 (26.3)	15/19 (78.9)	0.79	
Leader recognized overall situation	2/19 (10.5)	18/19 (94.7)	0.84	
Overall estimation for leadership	7/38 (18.4)	33/38 (86.8)	0.82	<0.001
Teamwork				
Team had good communication skill	7/19 (36.8)	19/19 (100)	0.10	
Team act to treat together	19/19 (100)	19/19 (100)	1.00	
Team controlled their emotion	18/19 (94.7)	19/19 (100)	1.00	
Team was positive	11/19 (57.9)	18/19 (94.7)	0.19	
Team agreed with changing their role followed changing situation	7/19 (36.8)	19/19 (100)	0.49	
Team frequently re-evaluated patient' s condition	11/19 (57.9)	17/19 (89.5)	0.52	
Team prepared for predictive deterioration of patient' s condition	10/19 (52.6)	7/19 (36.8)	0.53	
Overall estimation for teamwork	83/133 (62.4)	118/133 (88.7)	0.55	<0.001
Role				
Team set priorities for treatment	16/19 (84.2)	19/19 (100)	0.21	
Team followed guideline	0/19 (0)	18/19 (94.7)	0.95	
Overall estimation for role	16/38 (42.1)	37/38 (97.4)	0.58	<0.001

room lecture for the residents, while most nurses were never exposed to learning organophosphate poisoned patient care.

Comparison between pre- and post-education is shown in Table 3. All 19 groups achieved the MPS of 75%. The SBL program demonstrated improved performance rate for both the overall management and cooperative moods competency after implementation of the program (p<0.01). Inter-rater agreement between the two evaluators was excellent as well.

Comparisons for each item for team performance before and after learning program are shown in Table 4. All items were significantly improved except 'initial physical examination & monitoring apply'. Although there was high inter-rater agreement between the two evaluators, some items seem to be showing lower agreement scores.

Table 5 shows improvement of cooperative mood after the SBL program implementation. There was high inter-rater agreement between the two evaluators, but lower agreement scores compared to the team performance evaluation.

Discussion

As an educational strategy, simulation provides the opportunity for both immersive and reflective learning. Thus, to improve education and ultimately enhance patient safety, healthcare professionals are using simulation in many forms, such as mannequin-based simulations, computer-based simulations, and virtual patients. It is an effective learning tool to help the modern healthcare professional achieve higher levels of competence and safer care. SBL program have grown and matured over the past 40 years on substantive and methodological grounds[10]. High-fidelity medical simulations are educationally effective and simulation-based education compliments medical education in patient care settings[11]. SBL research groups are emerging in many medical specialties, including anesthesiology, emergency medicine (EM), internal medicine, obstetrics, pediatrics and surgery. Many of the skills being taught with the help of simulators are transferable to EM: airway, trauma, crisis management, medical error, ethics, and team performance[12]. Although simulation is used widely in EM education and training, limited reports are published regarding simulation implementation to clinical toxicology.

Halm et al[13] reports on medical student toxicology knowledge and self-confidence improvement after a mannequin-based simulation training. But no study

to date reports on the effectiveness of SBL on critical toxicology patients for ED healthcare providers. SBL has its role in teaching the 6 core areas of competency set by Accreditation Council for Graduate Medical Education[14]. Moreover, simulation has the potential to recreate scenarios that are rarely experienced and test professionals in challenging situations and to carefully replay or examine their actions[12]. SBL is being used in rare but critical clinical events to enhance the competencies of healthcare providers[15-18]. In a study by Cain et al[17], simulation teaching provided operation room personnel with an opportunity for skill development, teamwork, interdisciplinary communication, and problem solving in a malignant hyperthermia crisis, which is a rare, life-threatening event. Another study by Burns et al[16], proved that mannequin-based simulation was a novel method for teaching pediatric residents sickle cell disease acute care skills. Our study provided an opportunity for the ED healthcare providers to experience the critical component of an organophosphate poisoned patient, and to develop the skills, knowledge, and attitudes needed to provide safe and proper care.

The realism of the simulator places real stress and time pressure on the teams, which is critical for training them to function in an actual crisis or critical care situation[19]. Creating a realistic learning environment, and scenarios that were relevant to the residents and nurses, participants exhibited high performance competency in managing organophosphate poisoned patient (Table 6). Through simulation and face-to-face debriefing with the designated educator, participants recognized the importance of critical toxicology patient care. Key points in this educational strategy were immersive and reflective learning. By engaging the participants to the scenario, evaluator and educator were able to assess and record performances that were good and those that needed improvement. The reflection part comes during the debriefing session. Debriefing plays a critical role in facilitated reflection on simulation after the experiential component of SBL. The importance of its role in SBL is described in 2 systematic reviews[10-11].

The performance rate improved significantly after the learning intervention. The researchers set a minimum passing score (MPS) using the modified Angoff method[9]. The MPS was set to 75 percentage. All participants had to pass with scores at least 75% or more. All 19 groups achieved MPS. Most noticeable improvements were 'Precautionary measures', and 'Antidote'. Secondary contamination of ED personnel and other patients can happen. Therefore, every ED personnel need to be aware of potential hazardous materials threats[20]. In a recent review article by King et al[21], aggressive antimuscarinic therapy and oxime administration are the cornerstones of

Table 6. Simulation course evaluation (in one to five scale)

Question	Result (Mean±SD)
The scenario was similar to the real clinical situation	4.11±0.69
The equipment & materials were realistic	4.22±0.82
The simulation environment was realistic	3.86±0.76
Participants were absorbed in simulation situation	3.97±0.81
Participants behaved naturally like real clinical environment	3.95±0.87
This education was to be help to confirm my knowledge	4.68±0.47
This education was to be help to confirm my practical skill	4.19±0.79
This education was to be help to confirm my judgement	4.39±0.59
This education was to be help to confirm my merits and demerits	4.46±0.60
This education was to be help to confirm my overall clinical capacity	4.45±0.70
This education was to be help to confirm my communication skill	4.49±0.67
This education was to be help to realize importance of the teamwork	4.66±0.60
This education was to be help to confirm my clinical capacity	4.46±0.71
This education was to be help to confirm the importance of leadership	4.61±0.57
This education was to be help to confirm the importance of dispersion role	4.62±0.66

organophosphate poisoned patient management. Prescription of serum cholinesterase or pseudocholinesterase did not improve significantly after the intervention. This is probably due to the habit of prescribing the blood test as a whole single set, instead of a specific individual order. All the groups mentioned during debriefing that the serum level was included in the blood tests they prescribed during the running session. Out of the intended action, 'Initial physical examination & monitoring apply' did not improve significantly. Physical examination and patient monitoring is routine care of patients admitting to the ED, and therefore was not a relevant item to be included in the competency checklist. Most noticeable improvement in teamwork evaluation was 'Leadership' and 'Team following guideline'. This implies that the team recognized the importance of leadership and teamwork in caring for critically ill patient, and by standardizing patient care, the team will be able to achieve proper and timely care.

There are limitations to this study. First, the study was implemented to institutions near Seoul. Although 8 different hospitals from different locations were involved, we cannot generalize that this SBL program will work for other institutions in different areas and environment. Future planning is to open this program to other institutions and to provide the same opportunity to other ED healthcare professionals. Second, the evaluation was conducted as a group, not individually. Although critical patients are mostly managed as a team, we still need to assess and evaluate individual competencies. We also need to be specify the evaluation checklist in more detail. The kappa value for some of the checklist contents were low, meaning that there are contents that are difficult to evaluate objectively. Third, we did not see whether the learning transferred to actual clinical practice. Educational intervention research outcome that results in trainees' improvement in the education setting needs to be translated to the actual practice[23]. Unfortunately, this can be very difficult to achieve due to the rarity of clinical cases.

Conclusion

SBL program is an effective educational strategy that can be applied to improving and understanding proper care of rare but critical patient care. This program was effective in improving team performance and cooperative moods when managing an organophosphate poisoned patient in the ED.

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