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INSTRUCTIONAL DESIGN AND ASSESSMENT

Vital Sign Monitoring Using Human Patient Simulators at Pharmacy Schools in Japan

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Objective. To develop, implement, and assess an experience-based education program using human patient simulators to instruct pharmacy students in monitoring vital signs to identify drug treatment effects and adverse events.
Design. Medical emergency care programs using human patient simulators were prepared and facilitated practical clinical training in resuscitation, which required selecting drugs while monitoring changes in blood pressure, pulse, and arterial blood oxygen saturation. Training encompassed the monitoring of routes of drug administration, drawing of simulated blood, vital-sign monitoring based on a pharmaceutical universal training model, vital-sign monitoring devices and simulators, and medical emergency education using biological simulators.
Assessment. Before and after bedside training, students were asked to complete a questionnaire to assess their understanding of vital sign monitoring and emergency care. Students successfully learned how to monitor routes of drug administration, vital signs, and pathological conditions. There was a significant increase in students' recognition of the importance of vital-sign monitoring.
Conclusion. Experienced-based training using patient simulators successfully prepared pharmacy students to monitor vitals signs and identify drug treatment effects and adverse events.
Keywords: human patient simulator, vital signs, medical emergency care, practice experience, simulation

INTRODUCTION

In Japan, pharmacy education was redirected to focus on clinical instruction upon the transition to a 6-year pharmacy school curriculum in April 2006.[1] Previously, education had focused on the acquisition of basic pharmaceutical knowledge (mainly chemistry and biology) and clinical pharmaceutical education was not a major aim. However, when pharmacists began drug management guidance at medical facilities, they began to come in frequent contact with patients, physicians, and nurses. Drug management guidance involves instructing patients at their bedside in the use of drugs. It also encompasses the provision and recording of medication information in response to requests from physicians. A drug management guidance fee for services that meet specified conditions based on the patient's insurance score may be charged to Japan's Social Insurance Agency of the Ministry of Health, Labour and Welfare.

In Japan, academic institutions certify pharmacists who have finished specified training, given presentations, published reports, passed examinations as specialists of drugs, and displayed broad knowledge and sufficient technical skills. Those with sufficient knowledge and technical skills also are certified to be instructors of pharmacy student training. Beginning in 2006, academic associations also certify pharmacists with specialized knowledge and skills in each practical field, similar to the Board of Pharmaceutical Specialties in the United States. Because of the changes brought about by these new systems, pharmacists must acquire more extensive clinical skills than learned in pharmacy school.

Previously, pharmacists in Japan did not examine patients directly. However, it is now acknowledged that pharmacists should monitor patient vital signs to evaluate drug treatment effects and adverse events. Monitoring patients' vital signs is a fundamental activity for medical

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personnel. The "Vision of Medical Security for Confidence and Hope," developed by the Ministry of Health, Labour and Welfare, addresses the shortage of physicians in Japan,[2] and an interim report identified skill mix (shared tasks that can be performed by nonphysicians acting as co-medicals) as one approach to alleviating the shortage.[3] To provide efficient and safe medical care, pharmacists should be able to perform these patient services when providing pharmaceutical care.

To better equip pharmacy students with the skills they will need in practice in pharmacists' new role as co-medicals (medical personnel), Kyushu University of Health and Welfare's School of Pharmaceutical Sciences developed a program to train students to monitor patient vital signs to observe the effects of drugs and identify adverse events.[4] The clinical pharmaceutical training program uses human patient simulators and includes instruction in bedside monitoring of drug administration, vital-sign monitoring, blood drawing, and training in emergency medical procedures. Because pharmacists are frequently present at emergency care sites, they should acquire the same basic emergency care techniques as medical personnel. Clinical training in resuscitation includes selecting the correct drugs and determining their dose and timing of administration, while monitoring the patient's blood pressure, pulse, and arterial blood oxygen saturation (SpO_2). We report an experience-based program in pharmacy schools that uses simulators to teach vital-sign monitoring. Training in vital sign monitoring was required of all third-year pharmacy students as part of the Bedside Training Practice.

DESIGN

Monitoring the Route of Drug Administration

In the initial bedside training, rectal, subcutaneous, and intramuscular drug administration was monitored, and simulated blood was drawn. To monitor the students skills/techniques and administering drugs, we used a commercial universal training model, Sakura (Kyoto Kagaku Co., Ltd., Kyoto, Japan), which had been modified for pharmaceutical use. The modifications allowed (1) insertion of gastric tubes into gastric and intestinal fistulae, (2) addition of organs, (3) easy insertion of suppositories, (4) application of bedsore pads, (5) easier delivery of subcutaneous, intramuscular, and intravenous injections and monitoring of central venous nutrition by providing a greater number of puncture sites. For simulation of subcutaneous and intramuscular injections and drawing of blood, a subcutaneous pad/attachable brachial muscle injection simulator, Limit (Kyoto Kagaku Co., Ltd., Kyoto, Japan), and venous blood injection simulator, Shinjo (Kyoto Kagaku Co., Ltd., Kyoto, Japan) were used (Figures 1 and 2).

Figure 1. Pharmacy students practicing intramuscular injection using a simulator consisting of an attachment-type forearm.

Use of Vital-Sign Monitoring Devices and Simulators

During bedside training, techniques for measuring vital signs, including blood pressure, body temperature, pulse, and respiration, were taught using various vital-sign monitoring devices. The hemomanometers were a mercurial manometer (for auscultation of Korotkoff sounds) and an automatic manometer (with oscillometric arm band). Mercurial, electronic, ear, and instantaneous skin thermometers were used. A spirometer, peak flow meter, and vital capacity measurement device also were used. Detailed instructions on the use of the devices were provided by physicians from our university. Monitoring of blood pressure, pulse, and cardiac, respiratory, and intestinal sounds; electrocardiography; and examination of the pupillary reflex also were performed using a vital-sign simulator of heart

Figure 2. Pharmacy students practicing blood drawing using an intravenous injection simulator.

disease, Ichiro (Kyoto Kagaku Co., Ltd., Kyoto, Japan, 1 model), and the physical assessment model, Physico (Kyoto Kagaku Co., Ltd., Kyoto, Japan, 2 models).

Examining Pathological Conditions Using Biological Simulators

An advanced cardiac life support trainer (HeartSim, Laerdal Co, Ltd, Stavanger, Norway, 2 models) and a high-performance patient simulator (adult model, ECS Stan, METI Co., Sarasota, FL), was used to simulate cardiopulmonary resuscitation after ventricular fibrillation (VF), with recovery by adrenaline and oxygen administration. The high-performance patient simulator responds to drug administration and ventilation based on clinical pharmacokinetic and pharmacodynamic data; the characteristics of diseases and disorders and changes in vital signs closely resemble those of humans. We edited our original ventricular fibillation scenario (Table 1), and then programmed using software developed exclusively for the computer that accompanies the biological simulator (Table 2).

Use of Biological Simulators in the Preparation of Videos of Emergency Care Procedures

In the scenarios outlining the pathological conditions illustrated with the biological simulator, roles were assigned to physicians, nurses, and pharmacists so that the students could easily imagine performing the actions under the direction of an emergency team leader. We adopted drug treatment scenarios used in the advanced cardiac life support (ACLS) workshop sponsored by the Miyazaki Medical Association (Miyazaki, Japan), which were focused on accurate emergency care education (eg, a patient develops myocardial infarction and then ventricular fibrillation, and recovers after resuscitation and drug administration). The resuscitation method adhered to the American Heart Association's 2005 guidelines).[5] Instruments to facilitate treatment (defibrillator with a monitor and SpO_2 measurement device), related devices (face shield, cardiopulmonary resuscitation [CPR] board, Magill forceps, Ambu mask, endotracheal tube, intubation tube fixing device, stylet, and tube holder), drugs (adrenaline [Epiquick injection, 0.1%], dopamine [Predopa injection, 600 mg, physiological saline injection), syringes, and needles were used.

EVALUATION AND ASSESSMENT

Before and after bedside training, 128 students were asked to complete a questionnaire to assess their understanding of vital sign monitoring and emergency care. The items assessed included: (1) route of drug administration (tubal nutrition, injection route), (2) administration

Table 1. Original Scenario of the Program (Onset of Ventricular Fibrillation)

Myocardial Infarction, and Subsequently, Ventricular Fibrillation (VF)

Background: A 45-year-old male who underwent gastrofiberscopic hemostasis for hematemesis today developed an unpleasant chest sensation and called a physician. He suddenly lost consciousness and fell into cardiopulmonary arrest (CPA) immediately before consultation.

- Confirmation of VF by checking the airway, breathing, circulation, and defibrillation (ABCD of basic life support) (BLS, primary emergency care) → cardiopulmonary resuscitation (CPR) immediately after the first defibrillation (VF unchanged)
- Initiation of advanced life support (secondary emergency care)
  - A: Airway, the airway is manually secured.
  - B: Breathing, ventilation is maintained employing a bag valve mask. Please prepare for tracheal intubation as a precaution.
  - C: Circulation, a blood vessel is maintained for circulation (or maintenance via the median vein). Adrenaline is prepared.
  - D: Diagnosis, differential diagnosis
- Check items
  - Patient: Pale face. No apparent finding on the body surface
  - Medical record: Under oral medication for diabetes. Angina pectoris was previously pointed out.
  - Family: Currently in contact
- Persistence of VF → second defibrillation + continuation of CPR after adrenaline administration. Body movement appeared soon and re-start of the heart beat was confirmed.
- Vital sign check, investigation of the cause, and brain resuscitation after recovery of the heart beat
  - A: Airway, the airway is maintained, but there is regurgitation into the mouth.
  - B: Breathing, ventilation is insufficient because of the above condition → tracheal intubation or aspiration
  - C: Circulation, blood pressure in the 70s/pulse rate in the 120s → 0.3% dopamine at 6 mL/hr (60 kg body weight)
  - D: Diagnosis, chest X-ray photograph + electrocardiogram + blood gas
- The patient is sent to an intensive care unit (ICU) for brain resuscitation
  - 0.3% dopamine → intravenous drip infusion at 1-5 μg/kg/min. Dose increase up to 20 μg/kg corresponding to the patient's condition.

Table 2. Programming of the HeartSim ACLS Trainer[a]

Myocardial infarction: Post-ventricular fibrillation recovery program by cardiopulmonary resuscitation, adrenaline administration, and 0.3% dopamine administration.
Patient Discovery
Frame 0: Baseline for 30 seconds (70 bpm, 110/80 mmHg with respiratory sounds)
Frame 1: Ventricular fibrillation occurs (0 bpm, 0/0 mmHg with no respiratory sound) → consciousness check in the findings menu on the screen
Frame 2: Click emergency call in the treatment menu (doctor call, emergency cart, defibrillator with a monitor, backboard)
Frame 3: Artificial respiration with a bag valve mask and cardiopulmonary resuscitation by cardiac massage (15 seconds or longer cardiac massage (30 times) is detected)
Arrival of Emergency Team
Frame 4: Rhythm check in the treatment menu on the screen (confirmation of VF)
Frame 5: Defibrillation using a defibrillator with a monitor or pulse check
Frame 6: Cardiopulmonary resuscitation by cardiac massage (a 60-second or longer cardiac massage is detected)
Frame 7: Preparation of tracheal intubation in the treatment menu
Frame 8: Venous pathway check (a blood vessel is maintained) in the treatment menu
Frame 9: Checking using the defibrillator with a monitor → no heart beat recovery (0 bpm, 0/0 mmHg, no respiratory sound) → rhythm check in the treatment menu
Frame 10: Defibrillation using the defibrillator with a monitor or pulse check
Frame 11: Cardiopulmonary resuscitation by cardiac massage (a 60-second or longer cardiac massage is detected)
Frame 12: Epinephrine (=adrenaline) in the drug administration menu
Frame 13: Checking using the defibrillator with a monitor → heart beat recovery (120 bpm, 70/40 mmHg with respiratory sounds) → rhythm check in the treatment menu
Frame 14: Tracheal intubation or aspiration (instrument guidance)
Frame 15: Chest X-ray/electrocardiography in the treatment menu
Frame 16: Blood sampling/blood gas in the treatment menu
Frame 17: Frame duration of 30 seconds
Frame 18: 100 bpm, 100/70 mmHg → 0.3% dopamine in the drug administration menu
Frame 19: 120 bpm, 120/80 mmHg → sending to ICU for brain resuscitation
Frame 20: Return to baseline

[a] Programming the scenario in the ACLS trainer is enabled by the connection of "frames," which indicate the "patient's" vital signs, the medical treatment that must be performed, and the condition of the "patient" (simulator).

technique (rectal administration to a patient), (3) subcutaneous and intramuscular injections, (4) blood drawing, (5) vital-sign measurement devices (hemomanometer, thermometer, etc), (6) spirometer/peak flowmeter and vital capacity measurement device, (7) the Ichiro vital-sign simulator for heart disease examination, (8) the Physico physical assessment model, (9) the HeartSim ACLS trainer, and (10) the Stan high-performance patient simulator. Training in vital sign monitoring was required of all third-year pharmacy students as part of the bedside training practice.

After reading each item on the questionnaire, students placed a mark on a visual analog scale with endpoints "do not understand at all" and "completely understand" to indicate their degree of understanding using a conversion scale. The length of the line drawn by the student was calculated as a percentage for each item. Differences in the level of understanding before and after training were analyzed using the Wilcoxon rank-sum test. Results are presented in Table 3.

DISCUSSION

Experience-based instruction in vital-sign monitoring was provided to pharmacy students using various human patient simulators, and as a result, student recognition of the necessity of vital-sign monitoring significantly increased. Although our findings are based on students' self-assessments, we hope that an objective evaluation of student mastery of the techniques that comprise the training program can be conducted in the future.

In the posttraining self-assessment, the items that students understood best were (in descending order) vital-sign monitoring devices, monitoring route of drug administration, rectal drug administration, and the spirometer/peak flowmeter and vital capacity measurement device. In other words, understanding of items related to medical equipment and the pharmaceutical universal training model was high. Lower comprehension (in descending order) was reported for the vital-sign simulator of heart disease examination, Ichiro; blood drawing; the physical assessment model, Physico; subcutaneous and intramuscular injections; the

Table 3. Pharmacy Students' Self-Assessment of Their Knowledge of Monitoring Vital Signs to Identify Drug Treatment Effects and Adverse Events After Completing a Training Session Using Simulators, N=128

Questionnaire Item	Understanding (%)[a,b]	
	Preintervention	Postintervention
Checking and experience of various routes of administration		
Tubal nutrition and injection routes	30	80
Rectal administration to a patient	21	76
Subcutaneous and intramuscular injections	28	72
Blood sampling	22	70
Use of the following to perform vital sign checking		
Vital sign-related devices (hemomanometer, thermometer, others)	37	84
Spirometer/peak flowmeter and vital capacity measurement device	20	76
Vital sign simulator for heart disease examination, Ichiro	11	65
Physical assessment model, Physico	11	72
Checking of pathological conditions		
ACLS trainer, HeartSim	12	75
High-performance patient simulator, Stan	11	74

[a] Percentages based on students' responses using a visual analogue scale with endpoints "do not understand at all" and "completely understand" to indicate their degree of understanding.
[b] Comparisons for all items showed students' understanding significantly improved after undergoing training using simulators, $p < 0.01$ (Wilcoxon rank-sum test).

high-performance patient simulator, Stan; and the ACLS trainer, HeartSim. Understanding of the items related to the use of human patient simulators was low. However, student understanding increased for all items ($p < 0.01$, Table 1).

Regarding simulator-based education in other schools, a medical school in Singapore reported that the use of a patient simulator facilitated real-time visualization of patients' conditions, increased subsequent learning, and deepened student understanding.[7] In an international survey performed by an American nursing school, patient simulators were necessary at all levels of nursing education.[8] Simulation-based education of medical students was found to be superior to problem-based learning for the evaluation of emergency care and mastering of technique.[9]

As medical personnel, pharmacists must learn basic vital-sign monitoring and emergency care, thus, we prepared experience-based education programs using human patient simulators. These programs allow for training in vital-sign monitoring (pulse palpation, auscultation, blood pressure measurement, etc) to be part of the university curriculum. Mastering these techniques leads to the effective evaluation of drug treatment effects and the early discovery of adverse events. The programs also allow pharmacy students and pharmacists to experience medical treatment as a cooperative undertaking—one that is performed by a variety of health care workers. This leads to a better appreciation of the new role required of pharmacists in team-based medical care.

Experience-based education in vital-sign monitoring using simulators is essential for pharmacy students and practicing pharmacists. Accordingly, it is necessary for pharmacy schools to establish a continuing education system to offer instruction to practicing pharmacists.[10] We hope to offer our scenarios via download from the Laerdal Japan homepage; videos will be added later. Our experience suggests that pharmacy students are able to acquire fundamental techniques through this educational method, and to better understand their new role as members of a medical team.

SUMMARY

An experience-based education program to instruct pharmacy students in monitoring vital signs to identify drug treatment effects and adverse events was developed. Medical emergency care programs using simulators were prepared and used to facilitate clinical training in resuscitation, which required students to select drugs while monitoring changes in blood pressure, pulse, and arterial blood oxygen saturation. As a result, there was a significant increase in students' understanding of vital-sign monitoring. Experience-based education in vital-sign monitoring using simulators is essential for pharmacy students and practicing pharmacists.

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