Making programs of the rapid intravenous injection of potassium preparations and anaphylactic shock for an emergency-care simulator system

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Abstract

We made simulation programs to enable the reproduction of drug misadministration / condition changes for an emergency-care simulator system. We employed a Stan® simulator equipped with a personal computer. In these programs, the general clinical condition can be detected by blinking velocity, cardiac / respiratory sounds, heart / respiratory rate, body temperature and arterial blood pressure. As an example of drug misadministration, the simulation programs facilitated the reproduction of symptoms related to the rapid intravenous injection of potassium preparations. With respect to changes in clinical condition, it facilitated the reproduction of anaphylactic shock. These programs can be downloaded via the Internet. Experience of excess-dose drug administration / condition changes reproduced by the emergency-care simulator system is useful for checking patients' vital signs, and eventually for evaluating the drug efficacy, and confirming adverse reactions to drugs. Application of these programs will help teach pharmacy students how to check for vital signs (pulse palpation, auscultation, blood pressure measurement, and electrocardiography) in a school setting, not a hospital setting. Mastering these techniques may also allow pharmacy students to determine the efficacy of drug and adverse reactions.

Key words : simulator, drug administration, condition change, vital sign, simulation
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INTRODUCTION

In Japan, pharmaceutical education of licensed pharmacists was redirected toward clinical pharmaceutical education upon the transition from a 4-year to a 6-year pharmacy school curriculum in April 2006[1]. New pharmacists who completed the 6-year curriculum will graduate in March, 2012. Conventional pharmacy education has focused on the acquisition of basic pharmaceutical knowledge, and clinical pharmaceutical education was not a major aim. However, not only professional knowledge but also technological knowledge is required in a real medical scene. The conventional duties of Japanese pharmacists are different from ones of Japanese doctors and nurses, they do not directly examine patients. However, it is now acknowledged that pharmacists should monitor patient vital signs in order to evaluate drug treatment effects and adverse events. In other words the belief that a pharmacist should not directly examine a patient is decreasing. The monitoring of vital signs is a fundamental activity for medical personnel; it is a common language. Pharmaceutical education at Kyushu University of Health and Welfare, School of Pharmaceutical Sciences aims to train pharmacists to monitor vital signs to confirm the effects and adverse events of drugs[2-4]. We perform experience-based, bedside education as part of our clinical pharmacy training. In the bedside training, we performed confirmation of 1. various routes of administration, eg.;

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oral administration, rectal drug administration, mist dosage, subcutaneous / intramuscular drug administration, central venous feeding method, 2. drawing blood time / a blood-collecting vessel through a drawing blood experience of simulated blood, 3. vital sign monitoring using pharmaceutical universal training model, and vital sign monitoring devices and various simulators. We prepared simulation programs to enable the reproduction of drug misadministration / condition changes with an emergency-care simulator. This facilitated the palpation-, visual perception-, and auditory perception-mediated understanding of changes in the patient condition through fingertips and warnings / alarms on the monitor. These programs were conducted involving 50 students taking a hospital pharmacy course in the fifth grade within the Faculty of Pharmacy. We report on the results of simulation programs that we prepared and its evaluation by students.

METHODS

1. Preparation of Simulation Programs with an Emergency-Care Simulator

We employed an emergency-care simulator (an adult model ECS, Stan®, I.M.I Co., Ltd., manufactured by METI, Inc., U.S.A.). This simulator can reproduce vital sign changes and disease-related conditions of the human body, since a computer creates reactions to treatments such as drug administration and ventilation based on pharmacokinetic / -dynamic data. We initially developed the simulation program flow chart (Figure 1), and then programmed the simulation parameters into the emergency-care simulator software. Regarding the preparation of simulation programs, drug misadministration involved rapid intravenous injection of potassium preparations, and condition changes involved anaphylactic shock. The simulator general clinical condition was established using the blinking velocity, cardiac / respiratory sounds, heart / respiratory rate, body temperature and arterial blood pressure.

2. Program for rapid intravenous injection of potassium preparations

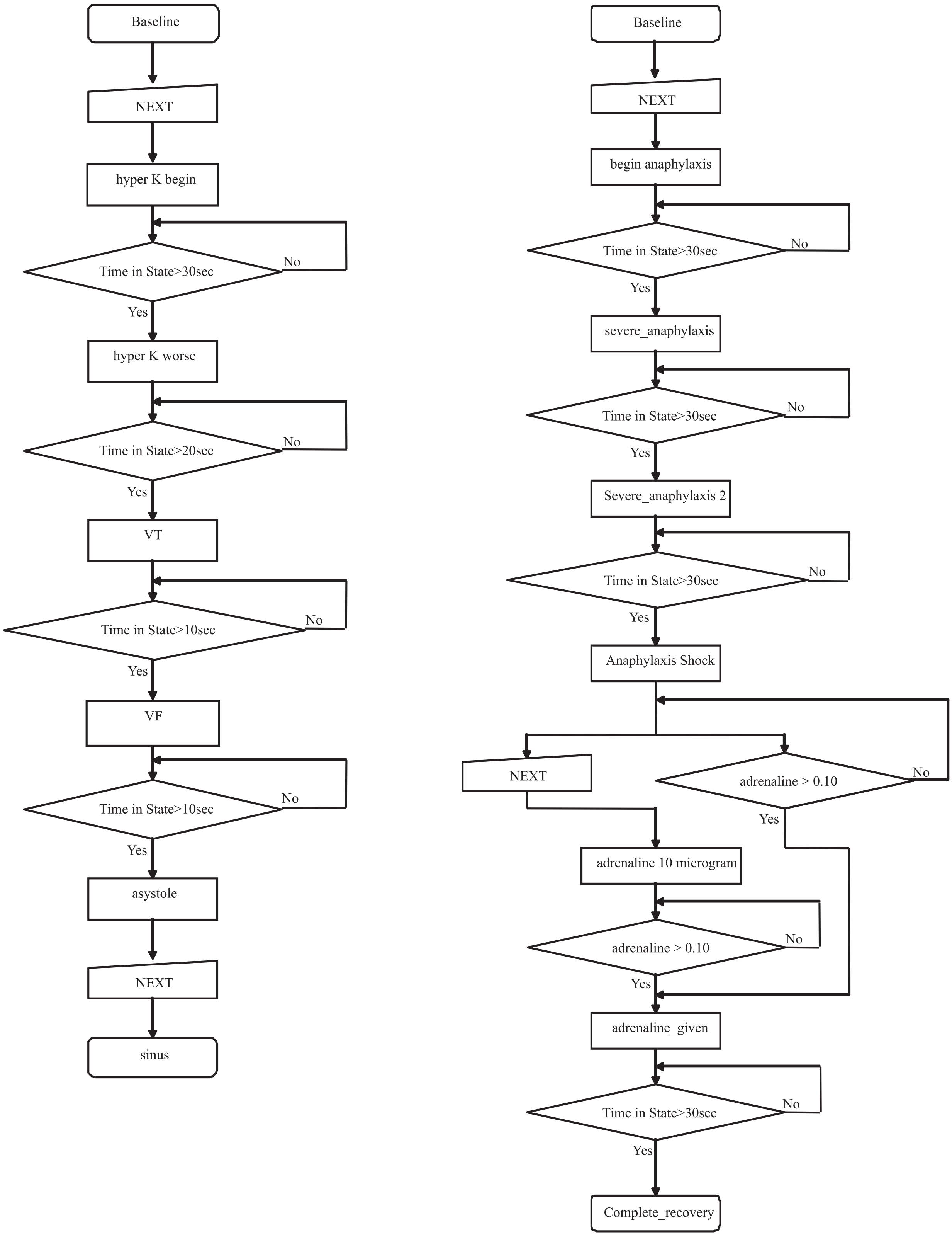
When clicking the mouse, the baseline (71 bpm, 114/52 mmHg, arterial blood oxygen saturation [SpO_2]: 99%) condition gradually changes to the condition after the rapid intravenous injection of potassium preparations. The eyes are closed approximately 10 seconds after administration, and the pulse and blood pressure gradually decrease (49 bpm, 73/26 mmHg, SpO_2: 98%), leading to ventricular tachycardia (VT) after 50 seconds. An alarm sounds, indicating that SpO_2 measurement is impossible. Subsequently, ventricular fibrillation (VF) and asystole (Asys) appear.

3. Program for anaphylactic shock

When clicking the mouse, the baseline (71 bpm, 114/51 mmHg, SpO_2: 99%, body temperature: 36.5℃) condition gradually progresses to anaphylactic conditions. Initially, stridor is confirmed using a stethoscope, and then, the pulse gradually increases, and the blood pressure decreases, leading to a rise in the body temperature and deep breathing. In addition, about 2 minutes later, an alarm sounds indicating SpO_2 reduction. The condition changed to serious anaphylactic shock (118 bpm, 69/32 mmHg, SpO_2 measurement: impossible, body temperature: 38.5℃).

4. Evaluation of the student training using the simulation system

These programs were conducted involving 50 students taking a hospital pharmacy course in the fifth grade within the Faculty of Pharmacy. We arranged for groups that consisted of six to eight students and one teaching staff member as an operator to experience a program for 90 minutes per time. Therefore, the demonstration for 90 minutes was carried out eight times over 2 days so that all students could experience it. A teaching staff operated the reproduction of these programs, and students could experience confirmation of the pulse rate, examination of the cardiac / respiratory sound by a stethoscope, and monitoring of blood pressure / SpO_2. Their knowledge of each program based on self-evaluation was retrospectively examined before and after the demonstration. The evaluation was conducted using the visual analog scale (VAS)[5]. The programs of interest were symptoms of rapid intravenous injection of potassium preparations and anaphylactic shock. To clarify their knowledge, the left-most column indicated "Not understand at all", and the



A Rapid intravenous injection of potassium preparations **B Anaphylactic shock**

Fig. 1. Flow chart of a simulation programs for rapid intravenous injection of potassium preparations (A, left) and anaphylactic shock (B, right).

right-most column indicated "Fully understand", and we asked the students to indicate their knowledge level by drawing a straight line with a highlighter pen. Regarding data on knowledge obtained from this, the length of the line which the responder drew with the highlighter pen as a percentage of the total line length was calculated for each item. We did not perform the examination using a emergency-care simulator, we investigate about the understanding degree only.

5. Statistical analysis

We used a Wilcoxon *t*-test about the difference of practice before and after in the understanding degree of each program contents, and analyzed them.

RESULTS

1. Preparation of Simulation Programs with an Emergency-Care Simulator

An increase in the ST-segment is observed before the appearance of VT. However, it was impossible to reproduce this using the "rapid intravenous injection of potassium preparations" program. We programmed the simulation so that a mouse click would trigger the conversion to normal sinus rhythm. This operation should be carried out when students, physicians or pharmacists indicate the intravenous injection of a calcium preparation, sodium bicarbonate, glucose / insulin therapy (GI therapy), or treatment with sodium polystyrene sulfonate. In the "anaphylactic shock" program, adrenaline can be administered by clicking the mouse so that recovery may be achieved after 2 minutes (90 bpm, 97/50 mmHg, SpO_2: 98%, body temperature: 37℃. We programmed the simulation so that a mouse click would trigger the conversion to normal sinus rhythm. Students were asked to say the instructions of medical treatment to shift to the conversion to normal sinus rhythm.

2. Evaluation of the student training using the simulation system

Table 1 shows the change in the level of knowledge for each program before and after the demonstration. As a result of evaluating the necessity, the line rates for symptoms of rapid intravenous injection of potassium preparations and anaphylactic shock were significantly increased from 40% (before the demonstration) to 67% (after the demonstration), 45% (before) to 72% (after), respectively ($p<0.01$).

Table 1 Change in the degree of the understanding of each program contents before and after the practice.

Self-evaluation of program contents	Degree of the understanding (%)	
	Before	After
Rapid intravenous injection of potassium preparations	40±2.9	67±2.9**
Anaphylactic shock	45±2.7	72±2.6**

Each value shows meam ± SE (n=50).
**, $p < 0.01$ (Wilcoxon *t*-test).

DISCUSSION

In these simulation programs regarding drug misadministration / condition changes with the emergency-care simulator, we utilized the characteristics of this simulator, such as blood pressure / pulse changes, eye-opening / closing, stridor, and deep breathing functions etc. As a result, we prepared 2 simulation programs. Evaluation of the students for these program contents increased significantly entirely ($p<0.01$).

Seybert et al. recently reported that PharmD courses in the U.S.A required training in blood pressure measurement[6)]. However, using simulator education to experience various condition changes by programming drug administration and condition changes, etc. has just been developed. We have reported on making the programs of the reproduction of condition about excess-dose insulin administration, asthma, hyperglycemia, hemorrhagic, and ventricular fibrillation so far[2, 4, 7)]. Regarding simulator-based education, 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[8)]. In an international survey performed by an American nursing school, it was reported that patient simulators were necessary at all levels of nursing education[9)]. It has also been reported that simulation-based education of medical students was superior to problem-based learning for the evaluation of emergency care and mastering of technique[10)].

There are many workshops that pharmacists can participate in: each hospital has its own original workshops, the Japanese Association for Acute Medicine ICLS (Immediate Cardiac Life Support) course, or the American Heart Association (AHA) health care provider course, which are held for medical staff for cardiopulmonary resuscitation. However, most workshops do not teach methods for confirmation of vital signs to medical staff. The Japanese Society of Hospital Pharmacists requests education for new pharmacist in the confirmation of vital signs through the College of Pharmacy. On the other hand, they also have policies that emphasize lifelong training workshops for pharmacists in a real medical scene. Therefore, we propose that the College of Pharmacy and Pharmacist Association should institute training in confirmation of vital signs for lifelong training workshops, as well as for pharmacy students, based on this investigation and past reports[11, 12]. We indicated that interest about confirmation of vital signs is high among hospital pharmacists and community pharmacists. From these results, we convinced that methods for confirming vital signs using a simulator and original scenarios are very useful.

The greatest problem with simulation education is cost. However, the importance of simulation education has been recognized, the numbers of universities that own a simulator will increase in Japan. Unfortunately, there seem to be many cases that cannot be managed using a simulator satisfactory. Our scenarios are available for download from the homepage of Kyushu University of Health and Welfare (https://www.pharm.phoenix.ac.jp/~cp2/dl.html). As medical personnel, pharmacists must learn basic vital sign monitoring and emergency care, and it is for this reason that we prepared experience-based education programs using original scenarios using an emergency-care simulator. Using these simulation programs, we are able to teach participants how to check for vital signs (pulse palpation, auscultation, blood pressure measurement, and electrocardiography).

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救急ケアシミュレータを用いたカリウム製剤急速静注とアナフィラキシーショックのプログラムの作成

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要旨

我々は、救急ケアシミュレータを使用した薬物誤投与・病態変化の再現が可能なシミュレーションプログラムを作成した。救急ケアシミュレータはスタン®を使用し、プログラムは操作専用パソコンを使用した。全身状態は、瞬き速度、心音、呼吸音および動脈温などでそれぞれ設定した。薬物誤投与に関しては、カリウム製剤急速静注の症状再現が可能となった。また、病態変化に関してはアナフィラキシーショックが再現可能となった。これらのプログラムはインターネットを介してダウンロードできる。救急ケアシミュレータを用いた薬物過量投与・病態変化の体験は、患者のバイタルサインの確認、薬効評価や薬物有害反応の確認に有用である。これらのプログラムの実行は、病院ではない学内において脈診、聴診、血圧測定、心電図所見といったバイタルサインの確認のトレーニングを可能にし、これらの技術の修得は薬学生の薬効評価や副作用の早期発見につながるであろう。

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