Brief Communication

Development, implementation, and refinement of a comprehensive postcardiac arrest care training course in Japan

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Aim: In Japan, no training course is dedicated to postcardiac arrest care (PCAC), including venoarterial extracorporeal membrane oxygenation (VA-ECMO); thus, faculty members of the Japanese Circulation Society developed an original, comprehensive PCAC training course. This report reviews the development, implementation, and refinement of this PCAC training course.

Methods: We examined the preserved data from the Japanese Circulation Society PCAC training courses between 2014 and 2020. Data related to the learning content and number of the attendees and instructors were collected and summarized.

Results: Sixteen courses were held between August 2014 and February 2020, before the coronavirus disease 2019 (COVID-19) pandemic. A total of 677 health care providers participated: 351 doctors, 225 nurses, 62 perfusionists, five emergency medical professionals, and two pharmacists. Thirty-two attendees' data were missing. The core learning contents of all the courses included a standardized postcardiac arrest algorithm, targeted temperature management, VA-ECMO cannulation skills, and postcannulation management. Concerning curriculum evolution, extracorporeal cardiopulmonary resuscitation simulation, postarrest neurological examination and monitoring, and ultrasound-guided Seldinger technique training were added in the 4th, 5th, and 13th courses, respectively.

Conclusion: The Japanese Circulation Society PCAC training course has been developed and refined to provide an organized, comprehensive opportunity for health care providers to acquire specific knowledge and skills in PCAC and VA-ECMO.

Key words: Cardiopulmonary resuscitation, postcardiac arrest syndrome, simulation training, targeted temperature management, venoarterial extracorporeal membrane oxygenation

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INTRODUCTION

SINCE 2001, POSTCARDIAC arrest care (PCAC) with targeted temperature management (TTM) has been a vital intervention to increase the possibility of favorable neurological outcomes for patients after cardiac arrest.[1,2] In 2008, postcardiac arrest syndrome was recognized and defined as a complicated, multisystem injury requiring a comprehensive bundle of care, including TTM.[3] From 2010, the International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations recommended postcardiac arrest intensive care for patients achieving a return of spontaneous circulation (ROSC), with refinements published in 2015 and 2020.[4] In the meantime, venoarterial extracorporeal membrane oxygenation (VA-ECMO) was implemented to treat refractory cardiac arrest, called extracorporeal cardiopulmonary resuscitation (E-CPR), and circulatory failure after ROSC.[5–7] The SAVE-J study, recognized as a landmark study for E-CPR, demonstrated the efficacy of E-CPR and revealed that E-CPR was frequently implemented in Japan.[8,9]

Despite the common practice, in Japan, standardized PCAC training modules and dedicated VA-ECMO/E-CPR training courses had not been established as of 2014. The Japanese Circulation Society (JCS) faculty members who were experienced cardiologists dedicated to emergency cardiopulmonary care and CPR education designed appropriate learning content and developed a 1-day PCAC training course. Since 2014, the course has evolved and been refined over six subsequent years. This report aims to review and describe the development, implementation, and refinement of the JCS PCAC training course.

METHODS

WE RETROSPECTIVELY EXAMINED the preserved data of the JCS PCAC training course from 2014 to 2020. Data related to the learning content, specialty, and number of attendees and instructors were collected and summarized.

Ethical consideration

This study was approved by the Institutional Review Board of Tohoku Medical and Pharmaceutical University (approval number 2016-2-029). As data were anonymously extracted, the requirement of participant informed consent for this study was waived.

RESULTS

SIXTEEN JCS PCAC training courses were held in Japan between August 2014 and February 2020. The first course comprised four learning sessions. Intermittently, some content was changed or added over time. E-CPR simulation, neurological examination and monitoring, and ultrasound-guided needle puncture training were added to the 4th, 5th, and 13th courses, respectively. The final course (February 2020) had eight sections in total (Table 1).

A total of 677 health care providers participated in 16 courses: 351 (51.9%) doctors, 225 (33.2%) nurses, 62 (10.8%) perfusionists, 5 (<1%) emergency medical professionals, and 2 (<1%) pharmacists. Thirty-two (4.7%) attendees had missing data. A total of 439 instructors participated in the 16 courses (Table 1). The number of attendees from each specialty is shown in Table 1. In the 2nd, 3rd, 4th, 5th, and 9th courses, nurses comprised the highest percentage of attendees. In the last six courses, more than half of the attendees were doctors.

Precourse learning materials

For precourse preparation, the textbook for this course was published in 2014, and attendees studied this ahead.[10] Additional precourse e-learning materials, including PDF files and videos for each section, were prepared.

Learning content

The 10 learning content sections are as follows:

1. Quality of CPR: The attendees handled several CPR feedback and commercially available near-infrared spectroscopy devices.
2. Mechanical compression device: Attendees set up and ran the mechanical compression devices on a CPR mannequin.
3. Airway and ventilation management: Attendees performed endotracheal intubation with video laryngoscopes and the waveform capnography monitoring.
4. TTM with specific devices: Attendees learned about the basic operation of specific TTM devices, including surface and intravascular cooling devices (Fig. 1).
5. Circulatory support with VA-ECMO and intra-aortic balloon pumping: Attendees experienced priming of the ECMO circuit and cannulation procedures utilizing a vascular model installed on a simulator (Fig. 1).[11]
6. PCAC scenario team training (ventricular fibrillation to ROSC): In teams, the attendees performed PCAC using

Table 1. Course information

Number of the training course	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Place	Shizuoka	Osaka	Hokkaido	Miyagi	Tokyo	Ishikawa	Osaka	Osaka	Osaka	Osaka	Tokyo	Tokyo	Tokyo	Tokyo	Osaka	Osaka
Year	2014	2015	2015	2016	2016	2017	2018	2018	2018	2018	2019	2019	2019	2019	2020	2020
Learning contents																
Quality of CPR	○	○		○							○	○				
Mechanical compression device	○	○		○									○	○	○	○
Airway and ventilation management		○		○	○	○	○	○	○	○	○	○				
TTM with specific devices	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Circulatory support with VA-ECMO	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
PCAS scenario team training	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Cerebral monitoring after ROSC					○	○	○	○	○	○	○	○	○	○	○	○
Neurological examination after ROSC					○	○	○	○	○	○	○	○	○	○	○	○
Ultrasound-guided needle puncture													○	○	○	○
E-CPR scenario				○	○	○	○	○	○	○	○	○	○	○	○	○
Number of attendees, *N*	67	60	33	43	45	41	45	36	48	31	25	27	42	46	42	46
Doctors, *n*	45	17	12	20	14	22	22	22	12	12	16	19	25	38	29	26
Nurses, *n*	15	26	16	20	30	15	14	11	18	13	6	6	9	7	8	11
Perfusionists, *n*	6	6	5	3		1	9	3	6	2	2	1	4	1	4	9
Pharmacists, *n*						1							1			
Emergency medical technicians, *n*	1				1	2			1							
Missing classification, *n*		11							11	4	1	1	3		1	
Number of instructors, *n*	25	26	21	38	24	29	33	33	32	32	24	24	24	24	25	25

This table presents the learning content in each course and the number of attendees and instructors.
CPR, cardiopulmonary resuscitation; E-CPR, extracorporeal cardiopulmonary resuscitation; PCAS, postcardiac arrest syndrome; ROSC, return of spontaneous circulation; TTM, targeted temperature management; VA-ECMO, venoarterial extracorporeal membrane oxygenation.

the simulator and implemented a comprehensive PCAC algorithm with subsequent debriefing.

7. Cerebral monitoring after ROSC: Attendees learned the importance of preventing secondary brain injury and nonconvulsive status epilepticus along with that of continuous electroencephalogram monitoring.
8. Neurological examination after ROSC: Attendees learned about several neurological assessment scores on a standardized patient.
9. Ultrasound-guided needle puncture: Attendees experienced ultrasound-guided needle puncture and guidewire insertion (the Seldinger technique) using a gel-pad training model to prepare for ECMO cannulation.
10. Full-scale E-CPR simulation: In teams, attendees were required to treat patients with persistent ventricular fibrillation using the VA-ECMO, with subsequent debriefing (Fig. 1, Table 2).

DISCUSSION

PCAC WITH TTM and VA-ECMO for circulatory failure or E-CPR requires a complex, multidisciplinary approach; health care providers responsible for these procedures should obtain specific knowledge and skills related to their roles. However, standardized educational opportunities for PCAC had not been developed before 2014 in Japan.

The advantage of the JCS PCAC training course is that it provides an intensive, dedicated, and hands-on opportunity to learn updated, comprehensive PCAC using the TTM algorithm and the logistics of VA-ECMO/E-CPR management using currently available medical devices. Furthermore, the learning content was refined to address post-ROSC neurological evaluation and monitoring. Finally, ultrasound-guided ECMO cannulation training was added to optimize safety cannulation skills.

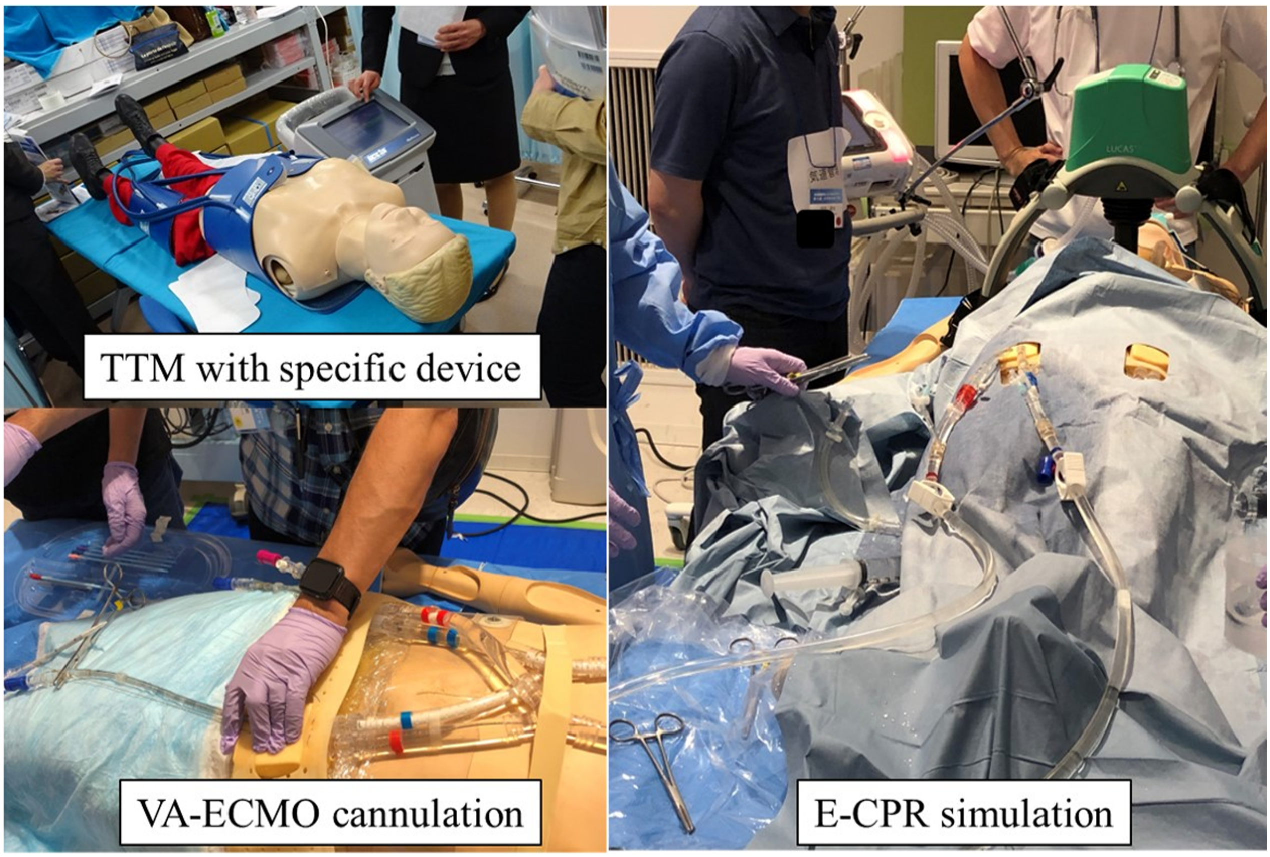

Fig. 1. Photographs of actual sessions from the seminar: TTM with specific device (left above), VA-ECMO cannulation (left below), E-CPR simulation (right). E-CPR, extracorporeal cardiopulmonary resuscitation; TTM, targeted temperature management; VA-ECMO, venoarterial extracorporeal membrane oxygenation.

Table 2. E-CPR simulation scenario

Time	Simulator rhythm	Team action CPR/ Defibrillation/Drugs	Quality assessment of CPR	ECMO	Ultrasound/Chest radiography/ CT
Scenario Presentation and Team Building (5 min)					
Before ECMO, 5–10 min	Shock-resistant VF	• Manual CPR by EMTs • Additional defibrillations • Amiodarone administration • Endotracheal intubation • Transition to mechanical CPR	• CPR feedback device • NIRS monitoring • $EtCO_2$ monitoring	• Vascular sheath insertion into the femoral artery and vein	• Ultrasound: no tamponade, no flap in the aorta • Ultrasound-guided venipuncture
ECMO cannulation and initiation, 15–20 min	Shock-resistant VF	• More epinephrine, if needed • More defibrillations, if needed • Heparin administration • Insertion of right, radial arterial catheter, if possible	• Targeted values • NIRS >50 • $EtCO_2 > 20$	• ECMO priming • Cannulation with ultrasound and/or fluoroscopy • Arterial 15–18 Fr • Venous 19–24 Fr • Initiation of ECMO	• Ultrasound-guided guidewire placement • Confirmation of cannulae placement by portable chest radiography
Post-ECMO management, 10 min	VF amplitude gets bigger, converts to organized rhythm after PCI and defibrillation	• Termination of CPR • Defibrillation after ECMO initiation (failed) • Transfer to cardiac catheterization laboratory • Core temperature monitoring and initiation of cooling • Sedative/Analgesia/Muscle relaxant	• $EtCO_2 \fallingdotseq 0$ on ECMO • NIRS >60% on ECMO • Mean arterial pressure >40 mmHg on ECMO	• Pump flow: 2.5–4.0 L/min • Heat exchanger for TTM	• Brain and body CT if needed • Ultrasound: detailed examination to assess native heart condition and function
Debriefing and wrapping up (20 min)					

This table presents the details of the e-CPR simulation scenario for instructors.
CPR, cardiopulmonary resuscitation; CT, computed tomography; ECMO, extracorporeal membrane oxygenation; E-CPR, extracorporeal cardiopulmonary resuscitation; EMTs, emergency medical technicians; $EtCO_2$, end-tidal carbon dioxide; NIRS, near-infrared spectroscopy; PCI, percutaneous coronary intervention; TTM, targeted temperature management; VF, ventricular fibrillation.

In a real E-CPR situation, ECMO cannulation during chest compressions is a highly technical procedure associated with a risk of serious complications. Therefore, ECMO cannulation training and E-CPR simulation are required for E-CPR practitioners. The increasing number of doctors in recent courses might be attributable to changes in the training content, including the focus on ECMO cannulation.

There were some course-associated disadvantages. First, the duration spent at each learning station was relatively short for attendees to appropriately experience the learning objective. Second, the frequency of this course remains inadequate for the number of dedicated health care providers.

Despite these disadvantages, improvements in knowledge, skill, and attitude have the potential to bring high-quality PCAC and VA-ECMO/E-CPR management into diverse working environments and save lives. Unfortunately, this course has been suspended since March 2020 owing to the coronavirus disease 2019 (COVID-19) pandemic. Faculty members are now planning to resume in-person training even during the COVID-19 pandemic.

Limitations

This study had several limitations. This course did not incorporate a post-test assessment; therefore, we could not evaluate the true acquisition of knowledge and skills. Participation in this course did not guarantee actual performance improvement in clinical settings. Further, regardless of the sophistication of the simulation, it cannot match the real-life stress and chaos of actual resuscitation. However, although these limitations exist, the learning content is specific and helpful to disseminate standard PCAC and VA-ECMO/E-CPR. To validate the true effect of this training, the long-term training effect on attendees' performance and improvements in PCAC quality at their institutions should be evaluated.

CONCLUSIONS

THE JCS PCAC training course was developed in 2014, and it was implemented and refined over the next 6 years. It was offered 16 times during this period. This course provided health care providers with the opportunity to acquire specific knowledge and skills for PCAC with TTM and VA-ECMO/E-CPR.

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DISCLOSURE

APPROVAL OF THE Research Protocol with approval No. 2016-2-029 and committee Name: This study was approved by the Institutional Review Board of Tohoku Medical and Pharmaceutical University.

Informed Consent: N/A.

Registry and the Registration No. of the study/Trial: N/A.

Animal Studies: N/A.

Conflict of Interest: Dr Endo reports lecture honoraria from Senko Medical Instrument, Terumo Corporation, and Laerdal Medical Japan, Dr Kikuchi reports honorarium for manuscript writing from Nihon Kohden. Dr Kasaoka reports lecture honorarium from Nihon Kohden. Dr Kuroda reports honorarium for manuscript writing from International Medical Intelligence Corporation and honorarium for educational events from Asahi Kasei ZOLL Medical Corporation. Dr Nagayama reports lecture honoraria from Takeda Pharmaceutical Company and Eisai Corporation.

REFERENCES

1 Hypothermia After Cardiac Arrest Study Group. Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest. N. Engl. J. Med. 2002; 346: 549–56.

2 Bernard SA, Gray TW, Buist MD *et al*. Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. N. Engl. J. Med. 2002; 346: 557–63.

3 Neumar RW, Nolan JP, Adrie C *et al*. Post-cardiac arrest syndrome: epidemiology, pathophysiology, treatment, and prognostication. A consensus statement from the International Liaison Committee on Resuscitation (American Heart Association, Australian and New Zealand Council on Resuscitation, European Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Asia, and the Resuscitation Council of Southern Africa); the American Heart Association Emergency Cardiovascular Care Committee; the Council on Cardiovascular

Surgery and Anesthesia; the Council on Cardiopulmonary, Perioperative, and Critical Care; the Council on Clinical Cardiology; and the Stroke Council. Circulation. The Council on Clinical Cardiology. Council Clin Cardiol 2008; 118: 2452–83.

4 Soar J, Berg KM, Andersen LW *et al*. Adult advanced life support: 2020 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. Resuscitation 2020; 156: A80–119.

5 Lamhaut L, Hutin A, Puymirat E *et al*. A Pre-Hospital extracorporeal cardio pulmonary resuscitation (ECPR) strategy for treatment of refractory out hospital cardiac arrest: an observational study and propensity analysis. Resuscitation 2017; 117: 109–17.

6 Yannopoulos D, Bartos J, Raveendran G *et al*. Advanced reperfusion strategies for patients with out-of-hospital cardiac arrest and refractory ventricular fibrillation (ARREST): a phase 2, single centre, open-label, randomised controlled trial. Lancet 2020; 396: 1807–16.

7 Stub D, Bernard S, Pellegrino V *et al*. Refractory cardiac arrest treated with mechanical CPR, hypothermia, ECMO and early reperfusion (the CHEER trial). Resuscitation 2015; 86: 88–94.

8 Morimura N, Sakamoto T, Nagao K *et al*. Extracorporeal cardiopulmonary resuscitation for out-of-hospital cardiac arrest: a review of the Japanese literature. Resuscitation 2011; 82: 10–4.

9 Sakamoto T, Morimura N, Nagao K *et al*. Extracorporeal cardiopulmonary resuscitation versus conventional cardiopulmonary resuscitation in adults with out-of-hospital cardiac arrest: a prospective observational study. Resuscitation 2014; 85: 762–8.

10 [Training Manual of Post Cardiac Arrest Care and Therapeutic Hypothermia] Shinteishi go kea to teitaion ryoho toreiningu manyuaru (in Japanese). Tokyo, Japan: Japan Resuscitation Council; 2015.

11 Endo T, Kagaya Y, Arata Y, Imai H. Long-term efficacy of an extracorporeal membrane oxygenation simulation with a novel, low-cost vascular model "Endo-Circuit". Acute Med. Surg. 2017; 4: 79–88.