Original Article

Changes in pre- and in-hospital management and outcomes for out-of-hospital cardiac arrest between 2002 and 2012 in Kanto, Japan: the SOS-KANTO 2012 Study

SOS-KANTO 2012 Study Group

Aim: The current study compares pre- and in-hospital management and outcomes of out-of-hospital cardiac arrest cases between 2002 and 2012 in the Kanto region of Japan.

Methods: We compared the data collected for the SOS-KANTO study project in 2002 and 2012. We included adult patients (aged >18 years) who experienced bystander-witnessed out-of-hospital cardiac arrest of cardiac etiology. The outcomes were as follows: proportion of favorable neurological outcomes at 1 month, bystander cardiopulmonary resuscitation provision, and pre- and postresuscitation treatment administration.

Results: Of 4,171 patients (1,982 in SOS-KANTO in 2002 and 2,189 in 2012), the proportion of those with favorable neurological outcomes at 1 month (4.8% versus 9.0%, $P < 0.001$), and bystander cardiopulmonary resuscitation rates increased significantly between 2002 and 2012 (24.5% versus 38.9%, $P < 0.001$). Although none were documented in 2002, 118 cases (5.4%) of layperson use of an automated external defibrillator were recorded in 2012. Relative to 2002, use of an i.v. line to provide fluid was more frequently attempted and carried out successfully by emergency medical service providers in 2012. Among cases in which return of spontaneous circulation was achieved, more postresuscitation treatment was provided in 2012 (13.3% versus 43.8%, $P < 0.001$) relative to that provided in 2002.

Conclusions: Proportions of bystander cardiopulmonary resuscitation, layperson use of automated external defibrillator, provision of prehospital adrenaline and postresuscitation treatment, and favorable neurological outcomes at 1 month increased significantly over 10 years in the Kanto region of Japan.

Key words: Adrenaline, automated external defibrillator, emergency medical services, extracorporeal life support, hypothermia

OUT-OF-HOSPITAL CARDIAC ARREST (OHCA) affects approximately 300,000, 280,000, and 100,000 people annually in the USA,¹ Europe,² and Japan,³ respectively. The survival rate of OHCA victims remained low until the early 2000s.⁴ However, the past 10 years have witnessed the advancement of OHCA studies using large data, which have shown drastic improvement in OHCA survival rates in

locations globally, including the USA,⁵ Europe,^{6,7} and Asia.^{8–11} Large-scale studies have suggested that two factors are key to achieving improvement: bystanders' actions in prehospital settings,^{3,6–9,12,13} and postresuscitation care following hospital arrival.^{5,10,14} However, the majority of the evidence presented in these studies was derived from either pre- or in-hospital databases. Therefore, simultaneously assessing both the bystanders' actions in prehospital settings and postresuscitation care in hospital was infeasible. Assessing databases containing detailed pre- and in-hospital information may address this limitation and clarify chronologically changed factors associated with improved OHCA survival in the 10 years.

There were several major revisions to the International Liaison Committee on Resuscitation guidelines as well as the national guidelines produced by the Japan Resuscitation Council between 2000 and 2010.^{15–17} Furthermore, there were several policy and law changes in Japan between 2002 and 2012. Following the release of the 2005 and 2010

This article is based on a study first reported in "Changes in pre- and in-hospital management and outcomes for out-of-hospital cardiac arrest between 2002 and 2012 in Kanto, Japan: The SOS-KANTO 2012 Study" on the KANTO Journal of the Japanese Association for Acute Medicine, 2014; 35 (2) 1–7, with the permission from the Chief Editor.

Corresponding: Takashi Tagami, MD, PhD, Department of Emergency and Critical Care Medicine, Nippon Medical School, 1-1-5 Sendagi, Bunkyo-ku, Tokyo 113-8603, Japan. E-mail: t-tagami@nms.ac.jp.

Received 12 Sep, 2014; accepted 25 Oct, 2014; online publication 17 February, 2015

cardiopulmonary resuscitation (CPR) guidelines,^{16,17} all Japanese fire stations with dispatch centers became more active with respect to dispatcher instruction to citizens carrying out CPR, under the Fire and Disaster Management Agency of the Internal Affairs and Communications Ministry of Public Management, in collaboration with the medical control system in each municipality.¹³ Automated external defibrillator (AED) use by citizens was approved in Japan in July 2004, and the number of publicly accessible AEDs increases annually.³ Since 2004, trained emergency medical service (EMS) providers have been permitted to carry out endotracheal intubation.¹⁸ Emergency medical service providers who are certified following training in a hospital have been permitted to administer adrenaline with remote instruction from a doctor since April 2006.^{19,20} In addition to the changes to these guidelines and laws, several Japanese publications were produced between 2002 and 2012 that may have influenced the hospital resuscitation process, particularly the use of extracorporeal membrane oxygenation both before and after return of spontaneous circulation (ROSC) has been achieved.^{10,21,22}

We carried out the survey of survivors after out-of-hospital cardiac arrest in the Kanto region (SOS-KANTO) study project in 2002, which included detailed information on 9,592 pre- and in-hospital cases.^{23–27} Ten years after the first study, we carried out the subsequent survey, the SOS-KANTO 2012 study, in the same region of Japan, to further cardiac arrest research. The key objective of the current report was to compare changes in laypeople's actions and the treatment offered by healthcare providers, in addition to related outcomes, in the Kanto area over 10 years. This article is based on a study first reported in the KANTO Journal of the Japanese Association for Acute Medicine (published in Japanese)²⁸ with the permission of the Chief Editor.

METHODS

Study design

THE PREVIOUS SURVEY (SOS-KANTO 2002) was undertaken in the Kanto region of Japan, which included 58 emergency hospitals and EMS units, with the support of the Kanto Regional Group of the Japanese Association for Acute Medicine between September 2002 and December 2003.^{23–27} The study was planned and carried out to accumulate pre- and in-hospital records of cardiac arrest patients who were admitted to hospitals in the Kanto region. We also conducted the current prospective survey project (SOS-KANTO 2012) in the Kanto region, which included 68 emergency hospitals, between January 2012 and March 2013. The current study was approved by the relevant insti-

tutional review boards of all 67 institutions, which waived the requirement for informed patient consent to ensure participant anonymity, which is stipulated in Japanese government guidelines.

Participants

The current study included patients aged >18 years who: experienced bystander-witnessed out-of-hospital cardiac arrest of cardiac etiology, which was confirmed by EMS providers at the scene; received CPR from EMS providers; and were subsequently transported to the participating institutions. Exclusion criteria were as follows: (i) cases with missing data regarding inclusion criteria or main outcomes (i.e., one month neurological outcome, whether bystander CPR was carried out or ROSC achieved); (ii) bystander CPR performed by health care providers or paramedics; (iii) onset of cardiac arrest subsequent to the arrival of paramedics or at the hospital; (iv) cases classified as Cerebral Performance Category (CPC) Scale categories 3 or 4 prior to cardiac arrest; (v) only respiratory arrest at the time of EMS provider arrival; or (vi) no treatment carried out at the participant hospital without the achievement of ROSC.

Definitions and data collection

Cardiac arrest was defined as the absence of mechanical cardiac activity, determined by an absence of pulse and normal breathing.²⁹ All cardiac arrest patients who were transported to the participant hospitals by EMS providers were included in both SOS-KANTO studies (2002 and 2012).^{23–27} Pre- and in-hospital treatments were generally provided to patients by EMS personnel, physicians, and other healthcare providers in line with the national guidelines of the Japan Resuscitation Council, which were based on the international guidelines in place at the relevant times (i.e., 2000 guidelines for SOS-KANTO 2002 and 2010 guidelines for SOS-KANTO 2012).^{15,17} The EMS providers collected prehospital information in the standardized Utstein style:²⁹ sex and age of the patient; initial cardiac rhythm; and the time course of resuscitation (e.g., the time of EMS providers' receipt of the emergency call, time of EMS providers' arrival on the scene, time of initial patient contact, and time of arrival at the hospital). Additional information included whether the arrest was witnessed by a bystander, a bystander initiated CPR, the patient was intubated, epinephrine was administered, and spontaneous circulation was restored before the patient arrived at the hospital. The EMS providers obtained additional information from the bystanders who performed CPR regarding whether they were trained in CPR or received dispatcher-assisted CPR instruction. The

bystander CPR technique was defined as documented chest compression, with or without rescue breathing, and unidentified CPR techniques. The rates and depths of chest compression could not be assessed.

Causes of cardiac arrest were determined by the physicians caring for the patients. Patients were diagnosed with cardiac arrest due to (presumed) cardiac etiology unless an obvious non-cardiac etiology was observed (i.e., cerebrovascular disease, respiratory disease, severe trauma, drowning, asphyxiation, or drug overdose). The institutional researchers collected in-hospital information: medications and interventions, return of spontaneous circulation subsequent to arrival at the hospital, hospital admission, laboratory data, duration of the hospital stay, and neurological outcome following initial cardiac arrest. Postresuscitation care was defined as therapeutic hypothermia and/or percutaneous coronary angiogram/intervention. Neurological outcomes were evaluated and reported using the CPC Scale; responses were scored as follows: category 1, good cerebral performance; category 2, moderate cerebral disability; category 3, severe cerebral disability; category 4, coma/vegetative state; category 5, death.²⁹

Outcome measures

The primary outcome measure was patient survival with minimal neurological impairment (favorable neurological outcome) at 1 month from cardiac arrest, which was defined as CPC Scale category 1 or 2. The secondary outcomes were proportions of bystander CPR provided, ROSC achieved, and pre- and postresuscitation treatments.

Statistical analysis

Baseline patient characteristics from SOS-KANTO 2002 and 2012 were compared using a χ^2 -test or Fisher's exact test for discrete variables, and a *t*-test or Mann–Whitney *U*-test for continuous variables, as appropriate. Significance was set at $P < 0.05$. All analyses were carried out using IBM SPSS version 22 (IBM, Armonk, NY, USA).

RESULTS

OF THE 26,044 patients who experienced cardiac arrests during the SOS-KANTO 2002 (9,592 patients) and 2012 (16,452 patients) study periods, 4,171 (1,982 in SOS-KANTO 2002 and 2,189 in SOS-KANTO 2012) met the inclusion criteria and were evaluated further (Fig. 1). Although the number of institutions that participated in the SOS-KANTO studies increased and the proportion of tertiary care emergency hospitals in participating institutions

decreased in 2012 (SOS-KANTO 2002 versus 2012; 55/58, 94.8% versus 51/67, 76.1%, $P = 0.004$), the change was not significant with respect to proportions of university hospitals (29/58, 50.0% versus 27/67 40.3%, $P = 0.28$).

Table 1 shows the baseline patient characteristics of the SOS-KANTO 2002 and 2012 groups. Patients were older, and the shockable rhythm rate was lower in the 2012 group relative to the 2002 group. Bystander CPR rates differed between the two study periods (24.5 versus 38.9%, $P < 0.001$). Among bystanders who performed CPR, the proportions of dispatcher-assisted CPR cases and individuals who had completed a CPR training course increased significantly in 2012 relative to those recorded in 2002. In addition, more hands-only CPR was performed in 2012 relative to 2002. Although no such cases were documented in 2002, 118 of all cases (5.4%) and 84 of the ROSC cases (8.9%) involved layperson AED use in 2012.

Table 2 shows prehospital (carried out by EMS providers) and posthospital treatments. The EMS dispatch-to-scene and scene-to-hospital times increased significantly in 2012 relative to 2002. Use of an i.v. line to provide fluid was more frequently attempted and successfully carried out by EMS providers in 2012 than it was in 2002. Of those whose i.v. lines were inserted by EMS providers, adrenalin was given to 81.8% (600/733) in prehospital settings in 2012 (no cases in 2002).

Relative to 2002, less atropine, sodium bicarbonate, and defibrillation were administered by physicians in 2012. However, more extracorporeal membrane oxygenation, coronary angiography/interventions, and therapeutic hypothermia were administered in 2012 relative to 2002. Return of spontaneous circulation was achieved more frequently in 2012 than in 2002 (36.3%, 720/1,982 versus 42.9%, 940/2,189, $P < 0.001$). Prehospital ROSC rates were higher in 2012 relative to those observed in 2002 (20.1%, 145/720 versus 29.0%, 273/940, $P < 0.001$). The incidence of postresuscitation treatment differed between the two study periods (13.3% versus 43.8%, $P < 0.001$) in cases in which ROSC was achieved (Table 3).

With respect to the primary outcome, rates of favorable neurological outcomes at 1 month (4.8%, 95/1,982 versus 9.0%, 195/2,189, $P < 0.001$) increased between 2002 and 2012 (Table 4). In addition, the rate of survival at 1 month increased (7.9%, 156/1,982 versus 12.7%, 277/2,189, $P < 0.001$) between the two study periods.

DISCUSSION

THE CURRENT RESULTS suggest improvements between 2002 and 2012 in achieving favorable neurological outcomes at 1 month in patients with bystander-

Fig. 1. Flow diagram of study groups that included adult patients (aged >18 years) who experienced bystander-witnessed out-of-hospital cardiac arrest of cardiac etiology. CPC, Cerebral Performance Category; CPR, cardiopulmonary resuscitation; EMS, emergency medical service.

witnessed out-of-hospital cardiac arrest of cardiac origin. The results also indicate that more laypeople took bystander CPR action in 2012 relative to 2002. Among those who performed bystander CPR, the number of people who performed dispatcher-assisted CPR increased significantly between the two study periods. Moreover, the provision of postresuscitation care at the hospital increased significantly.

The strength of the current study was the comparison of 2002 and 2012 data from two large databases, which were collected prospectively by corresponding EMS providers and hospital staff. Consequently, our databases included detailed pre- and in-hospital data from multiple institutions, located in the same region, during the implementation of two major revisions of resuscitation guidelines (the 2000 version was revised in 2005 and the 2005 version in 2010).^{15–17} In the revised resuscitation guidelines, prehospital and basic resuscitation processes have been simplified as follows: The “look, listen, and feel” approach was removed from the algorithms for layperson-administered CPR, hands-only CPR without rescue breathing was included, the compression-to-ventilation ratio changed from 15:2 to 30:2, the defibrillation sequence was reduced from three stacked shocks to a single shock, and avoidance of the

routine use of atropine and sodium bicarbonate was stipulated. However, postresuscitation care, including therapeutic hypothermia and percutaneous coronary intervention, was emphasized in the revised guidelines.^{15–17} The current results clearly represent these guideline changes.

One of the important findings of this study was that, in addition to the increase in the number of laypeople who had completed a CPR training course, the proportion of bystanders who carried out dispatcher-assisted CPR increased significantly, rising from 37.2% in 2002 to 53.9% in 2012. Accordingly, overall rates of bystander CPR administered to witnessed cardiac arrest victims increased from 24.5% to 39.3% in the study region. A few minutes of telephone advice, particularly in critically serious situations, actually changed the layperson’s actions, which may have been associated with the victim’s outcome. The dramatic increase in the provision of bystander CPR between 2002 and 2012 coincided with an increase in the rate of layperson AED use, prehospital adrenaline administration and ROSC, and postresuscitation care. Importantly, the proportion of patients who achieved ROSC and received postresuscitation treatment increased from 13.3% in 2002 to 43.8% in 2012.

Table 1. Patient demographics and event characteristics in SOS-KANTO 2002 and 2012

Characteristic	2002 (n = 1,982)	2012 (n = 2,189)	P-value
Age, mean (SD), years	65.7 (14.8)	69.5 (14.5)	<0.001
Male patients	1,482 (74.8)	1,557 (71.1)	0.009
Daytime	1,139 (57.5)	1,312 (59.9)	0.120
Location			0.100
Home	1,228 (62.0)	1,426 (65.1)	
Public space (indoor)	120 (6.1)	133 (6.1)	
Public space (outdoor)	221 (11.2)	238 (10.9)	
Others or unknown	413 (20.8)	392 (17.9)	
Relationship of bystander to patient			0.010
Family member or acquaintance	1,442 (72.8)	1,648 (75.3)	
Stranger	137 (6.9)	176 (8.0)	
Others or unknown	403 (20.3)	365 (16.7)	
Bystander CPR performed	486 (24.5)	852 (38.9)	<0.001
Hands-only dispatcher-assisted CPR	78 (16.0)	359 (42.1)	
Hands-only CPR with training course	34 (7.0)	142 (16.7)	
Hands-only CPR without assistance	79 (16.3)	151 (17.7)	
Conventional dispatcher-assisted CPR	77 (15.8)	34 (4.0)	
Conventional CPR with training course	79 (16.3)	77 (9.0)	
Conventional CPR without assistance	66 (13.6)	16 (1.9)	
None of the above or data missing	73 (15.0)	151 (17.7)	
Public-access defibrillation (layperson)	0 (0)	118 (5.4)	<0.001

CPR, cardiopulmonary resuscitation; SD, standard deviation.

This study had several limitations. First, although it was a prospective study, the sampling of approximately 70 hospitals was not random, and the dataset did not represent the entire region. However, overall survival rates and the patients' characteristics were similar to those of Japanese population-based reports that used prehospital data.^{9,12} In addition, rates of bystander CPR should not differ according to whether victims were transferred to the participant hospitals, because cardiac arrest is such a randomly occurring event, and a decision regarding the provision of bystander CPR should be made according to the bystander's capability, with or without the support of dispatchers, prior to the arrival of EMS providers. These EMS providers transfer the victim to the nearest emergency hospital that offers treatment for cardiac arrest. Therefore, our sample data from 67 hospitals should represent the region's patient population, at least with respect to prehospital information, including bystander CPR rates. Second, there were numerous data missing, which may have influenced the results of the analysis. Third, we only presented epidemiological data; consequently, we could not comment as to which factor may have contributed to the increase in survival rates.

In conclusion, rates of bystander CPR, layperson AED use, use of prehospital adrenaline and postresuscitation treat-

ment, and favorable neurological outcomes at 1 month increased significantly over 10 years in the Kanto region of Japan.

CONFLICT OF INTEREST

NONE.

ACKNOWLEDGEMENTS

THIS STUDY WAS supported by Japanese Association for Acute Medicine of Kanto. We thank the KANTO Journal of Japanese Association for Acute Medicine for permission to allow republication of this report. This article is dedicated to all the bystanders who undertook basic resuscitation, and to all firefighters, paramedics, nurses, physicians, and other healthcare professionals in the Kanto region who put their hearts and souls into saving the lives of others every day. We especially acknowledge Ms. Mai Matsumoto and the secretariat members of the Japanese Association for Acute Medicine of Kanto who helped us in collecting data and coordinating our project.

Table 2. Pre- and posthospital treatment prior to return of spontaneous circulation in adult patients (aged >18 years) who experienced bystander-witnessed out-of-hospital cardiac arrest of cardiac etiology

Characteristic	2002 (n = 1,982)	2012 (n = 2,189)	P-value
Call-to-EMS at the scene, median (IQR), min	8 (4)	9 (4)	<0.001
Scene-to-hospital arrival, median (IQR), min	17 (8)	25 (12)	<0.001
Initial rhythm documented by EMS, n (%)			<0.001
VF	674 (34.0)	552 (26.6)	
Pulseless electrical activity	426 (21.5)	571 (27.6)	
Asystole	882 (44.5)	949 (45.8)	
Airway management by EMS			<0.001
Bag valve mask	442 (22.3)	985 (45.0)	
Advanced airway management	1,539 (77.6)	1,089 (49.7)	
Others or unknown	1 (0.1)	115 (5.3)	
Prehospital defibrillation (layperson and EMS)	590 (29.8)	812 (37.1)	<0.001
Intravenous lines inserted by EMS			<0.001
Successfully performed	169 (8.5)	733 (33.3)	
Attempted but unsuccessful	276 (13.9)	616 (28.1)	
Not attempted	1,537 (77.5)	819 (37.4)	
Adrenalin administration			<0.001
None	132 (6.7)	257 (11.7)	
Prehospital only	0 (0)	109 (5.0)	
In-hospital only	1,850 (93.3)	1,178 (53.8)	
Both pre- and in-hospital	0 (0)	491 (22.4)	
Others and unknown	0 (0)	154 (7.0)	
Atropine administration	476 (24.0)	121 (5.5)	<0.001
Sodium bicarbonate administration	360 (18.2)	252 (11.6)	<0.001
Defibrillation performed at ER	519 (26.2)	504 (23.0)	0.010
Use of extracorporeal membrane oxygenation	39 (2.0)	177 (8.1)	<0.001

EMS, emergency medical services; ER, emergency room; IQR, interquartile range; VF, ventricular fibrillation/pulseless ventricular tachycardia.

Table 3. Postresuscitation treatments following return of spontaneous circulation in adult patients (aged >18 years) who experienced bystander-witnessed out-of-hospital cardiac arrest of cardiac etiology

Characteristic	2002 (n = 720)	2012 (n = 940)	P-value
Postresuscitation treatments administered			<0.001
None	624 (86.7)	242 (25.7)	
Coronary angiography/intervention only	39 (5.4)	104 (11.1)	
Therapeutic hypothermia only	37 (5.1)	71 (7.6)	
Both	20 (2.8)	237 (25.2)	
Unknown	0 (0)	286 (30.4)	

CONTRIBUTORS

TAKASHI TAGAMI, HIROYUKI Yokota, Masato Miyauchi, Asuka Tsuchiya, Taka-aki Nakada, Yoshiaki Inoue, Migaku Kikuchi, Atsushi Sakurai, Yoshio Tahara, Ken Nagao, Naohiro Yonemoto, Arino Yaguchi, Naoto Morimura

SOS-KANTO 2012 STEERING COUNCIL

YOKOHAMA CITY UNIVERSITY Medical Center, Kanagawa (President, Naoto Morimura MD); Nihon University School of Medicine, Tokyo (Director, Atsushi Sakurai MD); National Cerebral and Cardiovascular Center

Table 4. Outcomes in adult patients (aged >18 years) who experienced bystander-witnessed out-of-hospital cardiac arrest of cardiac etiology

	2002 (n = 1,982)	2012 (n = 2,189)	P-value
Return of spontaneous circulation achieved	720 (36.3)	940 (42.9)	<0.001
CPC Scale category after 1 month			<0.001
CPC 1	63 (3.2)	164 (7.5)	
CPC 2	32 (1.6)	32 (1.5)	
CPC 3	12 (0.6)	37 (1.7)	
CPC 4	49 (2.5)	44 (2.0)	
CPC 5	1,826 (92.1)	1,912 (87.3)	

Cerebral Performance Category (CPC) Scale:²⁹ category 1, good cerebral performance; 2, moderate cerebral disability; 3, severe cerebral disability; 4, coma/vegetative state; 5, death.

Hospital, Osaka (Director, Yoshio Tahara MD); Tokyo Women's Medical University Hospital, Tokyo (Arino Yaguchi MD); Nihon University Surugadai Hospital, Tokyo (Ken Nagao MD); Nippon Medical School Hospital, Tokyo (Tagami Takashi MD); Japanese Red Cross Maebashi Hospital, Gunma (Dai Miyazaki MD); National Disaster Medical Center, Tokyo (Tomoko Ogasawara MD); Keio University Hospital, Tokyo (Kei Hayashida MD, Masaru Suzuki MD); Tokai University School of Medicine, Kanagawa (Mari Amino MD); Kimitsu Chuo Hospital, Chiba (Nobuya Kitamura MD); Juntendo University Nerima Hospital, Tokyo (Tomohisa Nomura MD); Tokyo Metropolitan Children's Medical Centre, Tokyo (Naoki Shimizu MD); Tokyo Metropolitan Bokutoh Hospital, Tokyo (Akiko Akashi MD), National Center of Neurology and Psychiatry, Tokyo, Japan (Naohiro Yonemoto DPH).

SOS-KANTO 2012 STUDY GROUP

TOKAI UNIVERSITY SCHOOL of Medicine (Sadaki Inokuchi MD); St. Marianna University School of Medicine, Yokohama Seibu Hospital (Yoshihiro Masui MD); Koto Hospital (Kunihisa Miura MD); Saitama Medical Center Advanced Tertiary Medical Center (Haruhiko Tsutsumi MD); Kawasaki Municipal Hospital Emergency and Critical Care Center (Kiyotsugu Takuma MD); Yokohama Municipal Citizen's Hospital (Ishihara Atsushi MD); Japanese Red Cross Maebashi Hospital (Minoru Nakano MD); Juntendo University Urayasu Hospital (Hiroshi Tanaka MD); Dokkyo Medical University Koshigaya Hospital (Keiichi Ikegami MD); Hachioji Medical Center of Tokyo Medical University (Takao Arai MD); Tokyo Women's Medical University Hospital (Arino Yaguchi MD); Kimitsu Chuo Hospital (Nobuya Kitamura MD); Chiba University Graduate School of Medicine (Shigeto Oda MD); Saiseikai Utsunomiya Hospital

(Kenji Kobayashi MD); Mito Saiseikai General Hospital (Takayuki Suda MD); Dokkyo Medical University (Kazuyuki Ono MD); Yokohama City University Medical Center (Naoto Morimura MD); National Hospital Organization Yokohama Medical Center (Ryosuke Furuya MD); National Disaster Medical Center (Yuichi Koido MD); Yamanashi Prefectural Central Hospital (Fumiaki Iwase MD); Surugadai Nihon University Hospital (Ken Nagao MD); Yokohama Rosai Hospital (Shigeru Kanesaka MD); Showa General Hospital (Yasusei Okada MD); Nippon Medical School Tamanagayama Hospital (Kyoko Unemoto MD); Tokyo Women's Medical University Yachiyo Medical Center (Tomohito Sadahiro MD); Awa Regional Medical Center (Masayuki Iyanaga MD); Todachuo General Hospital (Asaki Muraoka MD); Japanese Red Cross Medical Center (Munehiro Hayashi MD); St. Luke's International Hospital (Shinichi Ishimatsu MD); Showa University School of Medicine (Yasufumi Miyake MD); Totsuka Kyoritsu Hospital 1 (Hideo Yokokawa MD); St. Marianna University School of Medicine (Yasuaki Koyama MD); National Hospital Organization Mito Medical Center (Asuka Tsuchiya MD); Tokyo Metropolitan Tama Medical Center (Tetsuya Kashiya MD); Showa University Fujigaoka Hospital (Munetaka Hayashi MD); Gunma University Graduate School of Medicine (Kiyohiro Oshima MD); Saitama Red Cross Hospital (Kazuya Kiyota MD); Tokyo Metropolitan Bokutoh Hospital (Yuichi Hamabe MD); Nippon Medical School Hospital (Hiroyuki Yokota MD); Keio University Hospital (Shingo Hori MD); Chiba Emergency Medical Center (Shin Inaba MD); Teikyo University School of Medicine (Tetsuya Sakamoto MD); Japanese Red Cross Musashino Hospital (Naoshige Harada MD); National Center for Global Health and Medicine Hospital (Akio Kimura MD); Tokyo Metropolitan Police Hospital (Masayuki Kanai MD); Medical Hospital of Tokyo Medical and Dental University (Yasuhiro

Otomo MD); Juntendo University Nerima Hospital (Manabu Sugita MD); Nihon University School of Medicine (Kosaku Kinoshita MD); Toho University Ohashi Medical Center (Takatoshi Sakurai MD); Saiseikai Yokohamashi Tobu Hospital (Mitsuhide Kitano MD); Nippon Medical School Musashikosugi Hospital (Kiyoshi Matsuda MD); Tokyo Rosai Hospital (Kotaro Tanaka MD); Toho University Omori Medical Center (Katsunori Yoshihara MD); Hiratsuka City Hospital (Kikuo Yoh MD); Yokosuka Kyosai Hospital (Junichi Suzuki MD); Saiseikai Yokohamashi Nambu Hospital (Hiroshi Toyoda MD); Nippon Medical School Chiba Hokusoh Hospital (Kunihiro Mashiko MD); Tokyo Metropolitan Children's Medical Centre (Naoki Shimizu MD); National Medical Center for Children and Mothers (Takashi Muguruma MD); Chiba Aoba Municipal Hospital (Tadanaga Shimada MD); Kuki General Hospital (Yoshiro Kobe MD); Matsudo City Hospital (Tomohisa Shoko MD); Japanese Red Cross Narita Hospital (Kazuya Nakanishi MD); Tokyo Bay Urayasu/Ichikawa Medical Center (Takashi Shiga MD); NTT Medical Center Tokyo (Takefumi Yamamoto MD); Tokyo Saiseikai Central Hospital (Kazuhiko Sekine MD); Fuji Heavy Industries Health Insurance Society OTA Memorial Hospital (Shinichi Izuka MD). (http://www.jaam-kanto.jp/sos_kanto/sos_kanto2012_contributors.html)

REFERENCES

- Nichol G, Thomas E, Callaway CW *et al.* Regional variation in out-of-hospital cardiac arrest incidence and outcome. *JAMA* 2008; 300: 1423–31.
- Atwood C, Eisenberg MS, Herlitz J, Rea TD. Incidence of EMS-treated out-of-hospital cardiac arrest in Europe. *Resuscitation* 2005; 67: 75–80.
- Kitamura T, Iwami T, Kawamura T, Nagao K, Tanaka H, Hiraide A. Nationwide public-access defibrillation in Japan. *N. Engl. J. Med.* 2010; 362: 994–1004.
- Sasson C, Rogers MA, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: A systematic review and meta-analysis. *Circ. Cardiovasc. Qual. Outcomes* 2010; 3: 63–81.
- Fugate JE, Brinjkji W, Mandrekar JN *et al.* Post-cardiac arrest mortality is declining: A study of the US National Inpatient Sample 2001 to 2009. *Circulation* 2012; 126: 546–50.
- Adielsson A, Hollenberg J, Karlsson T *et al.* Increase in survival and bystander CPR in out-of-hospital shockable arrhythmia: Bystander CPR and female gender are predictors of improved outcome. Experiences from Sweden in an 18-year perspective. *Heart* 2011; 97: 1391–6.
- Wissenberg M, Lippert FK, Folke F *et al.* Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. *JAMA* 2013; 310: 1377–84.
- Iwami T, Nichol G, Hiraide A *et al.* Continuous improvements in “chain of survival” increased survival after out-of-hospital cardiac arrests: A large-scale population-based study. *Circulation* 2009; 119: 728–34.
- Kitamura T, Iwami T, Kawamura T *et al.* Nationwide improvements in survival from out-of-hospital cardiac arrest in Japan. *Circulation* 2012; 126: 2834–43.
- Tagami T, Hirata K, Takeshige T *et al.* Implementation of the fifth link of the chain of survival concept for out-of-hospital cardiac arrest. *Circulation* 2012; 126: 589–97.
- Ro YS, Shin SD, Song KJ *et al.* A trend in epidemiology and outcomes of out-of-hospital cardiac arrest by urbanization level: A nationwide observational study from 2006 to 2010 in South Korea. *Resuscitation* 2013; 84: 547–57.
- Iwami T, Kitamura T, Kawamura T *et al.* Chest compression-only cardiopulmonary resuscitation for out-of-hospital cardiac arrest with public-access defibrillation: A nationwide cohort study. *Circulation* 2012; 126: 2844–51.
- Japanese Circulation Society Resuscitation Science Study Group. Chest-compression-only bystander cardiopulmonary resuscitation in the 30:2 compression-to-ventilation ratio era. *Circ. J.* 2013; 77: 2742–50.
- van der Wal G, Brinkman S, Bisschops LL *et al.* Influence of mild therapeutic hypothermia after cardiac arrest on hospital mortality. *Crit. Care Med.* 2011; 39: 84–8.
- Task Forces of the American Heart Association. Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Part 3: Adult basic life support. The American Heart Association in collaboration with the International Liaison Committee on Resuscitation. *Circulation* 2000; 102 (8 Suppl): I22–59.
- Task Forces of the American Heart Association. 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation* 2005; 112 (24 Suppl): IV1–203.
- Field JM, Hazinski MF, Sayre MR *et al.* Part 1: Executive summary: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation* 2010; 122: S640–56.
- Hasegawa K, Hiraide A, Chang Y, Brown DF. Association of prehospital advanced airway management with neurologic outcome and survival in patients with out-of-hospital cardiac arrest. *JAMA* 2013; 309: 257–66.
- Nakahara S, Tomio J, Takahashi H *et al.* Evaluation of pre-hospital administration of adrenaline (epinephrine) by emergency medical services for patients with out of hospital cardiac arrest in Japan: Controlled propensity matched retrospective cohort study. *BMJ* 2013; 347: f6829.
- Hagihara A, Hasegawa M, Abe T, Nagata T, Wakata Y, Miyazaki S. Prehospital epinephrine use and survival among patients with out-of-hospital cardiac arrest. *JAMA* 2012; 307: 1161–8.
- Save-J_Study_Group, Sakamoto T, Morimura N *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.
- 22 Maekawa K, Tanno K, Hase M, Mori K, Asai Y. Extracorporeal cardiopulmonary resuscitation for patients with out-of-hospital cardiac arrest of cardiac origin: a propensity-matched study and predictor analysis. *Crit. Care Med.* 2013; 41: 1186–96.
- 23 SOS-KANTO_study_group. Cardiopulmonary resuscitation by bystanders with chest compression only (SOS-KANTO): An observational study. *Lancet* 2007; 369: 920–6.
- 24 SOS-KANTO_study_group. Relationship between the hemoglobin level at hospital arrival and post-cardiac arrest neurologic outcome. *Am. J. Emerg. Med.* 2012; 30: 770–4.
- 25 SOS-KANTO_study_group. Incidence of ventricular fibrillation in patients with out-of-hospital cardiac arrest in Japan: Survey of survivors after out-of-hospital cardiac arrest in Kanto area (SOS-KANTO). *Circ. J.* 2005; 69: 1157–62.
- 26 SOS-KANTO_study_group. Comparison of arterial blood gases of laryngeal mask airway and bag-valve-mask ventilation in out-of-hospital cardiac arrests. *Circ. J.* 2009; 73: 490–6.
- 27 SOS-KANTO_study_group. Atropine sulfate for patients with out-of-hospital cardiac arrest due to asystole and pulseless electrical activity. *Circ. J.* 2011; 75: 580–8.
- 28 SOS-KANTO 2012 Study Group. Changes in pre- and in-hospital management and outcomes for out-of-hospital cardiac arrest between 2002 and 2012 in Kanto, Japan: The SOS-KANTO 2012 Study” on the KANTO Journal of the Japanese Association for Acute Medicine. 2014; 35: 1–7.
- 29 Jacobs I, Nadkarni V, Bahr J *et al.* Cardiac arrest and cardiopulmonary resuscitation outcome reports: Update and simplification of the Utstein templates for resuscitation registries: A statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian Resuscitation Council, New Zealand Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Councils of Southern Africa). *Circulation* 2004; 110: 3385–97.