Available online at www.sciencedirect.com

Resuscitation Plus

journal homepage: www.journals.elsevier.com/resuscitation-plus

EUROPEAN RESUSCITATION COUNCIL

Clinical paper

Comparison of clinical outcomes between patients with pulseless-ventricular tachycardia and ventricular fibrillation in out-of-hospital cardiac arrest

Yuta Kato[a,b,*], *Shin-ichiro Miura*[a], *Atsushi Hirayama*[b,c], *Chisato Izumi*[b], *Satoshi Yasuda*[b,d], *Yoshio Tahara*[b], *Naohiro Yonemoto*[e], *Hiroshi Nonogi*[f], *Ken Nagao*[g], *Takanori Ikeda*[h], *Naoki Sato*[i], *Hiroyuki Tsutsui*[j], *Yoshio Kobayashi*[k], *for the Japanese Circulation Society Resuscitation Science Study (JCS-ReSS) Group*

[a] Department of Cardiology, Fukuoka University School of Medicine, Fukuoka, Japan
[b] Department of Cardiovascular Medicine, National Cerebral and Cardiovascular Center, Osaka, Japan
[c] Public Health, Department of Social Medicine, Osaka University Graduate School of Medicine, Osaka, Japan
[d] Department of Cardiovascular Medicine, Tohoku University Graduate School of Medicine, Sendai, Japan
[e] Department of Epidemiology and Biostatistics, National Center of Neurology and Psychiatry, Tokyo, Japan
[f] Faculty of Health Science, Osaka Aoyama University, Osaka, Japan
[g] Cardiovascular Center, Nihon University Hospital, Tokyo, Japan
[h] Department of Cardiovascular Medicine, Toho University Faculty of Medicine, Tokyo, Japan
[i] Kawaguchi Cardiovascular and Respiratory Hospital, Saitama, Japan
[j] Department of Cardiovascular Medicine, Kyushu University, Fukuoka, Japan
[k] Department of Cardiovascular Medicine, Chiba University Graduate School of Medicine, Chiba, Japan

Abstract

Aim: While previous studies have shown that the initial documented rhythm is associated with clinical outcomes in out-of-hospital cardiac arrest (OHCA), little is known about the difference in clinical outcomes between pulseless ventricular tachycardia (p-VT) and ventricular fibrillation (VF).

Methods: From a nationwide, prospective population-based database of OHCA from 2011 to 2015, we selected bystander-witnessed adult patients who were not treated with a public automated external defibrillator. The outcomes examined were favorable 30-day neurological survival rates, 30-day survival rates, and prehospital return of spontaneous circulation (ROSC) rates. To determine the association of the initial documented rhythm with outcome, we used a logistic regression model while adjusting for patient factors and prehospital care-related factors.

Results: A total of 19,594 bystander-witnessed OHCA patients who had a shockable rhythm were included: 454 (2.3%) were p-VT and 19,140 (97.7%) were VF. Compared to VF patients, p-VT patients were older, less likely to have a cardiogenic cause, and had shorter resuscitation-related time intervals (collapse to bystander cardiopulmonary resuscitation, collapse to emergency medical services contact, collapse to first ROSC, and first defibrillation to first ROSC). After adjustment for covariates, p-VT was associated with high favorable 30-day neurological survival rates (adjusted odds ratio [OR], 1.85; 95% confidence interval [CI], 1.30−2.64, $p = 0.001$), 30-day survival rates (adjusted OR, 1.41; 95% CI, 1.03−1.95, $p = 0.037$), and prehospital ROSC rates (adjusted OR, 1.90; 95% CI, 1.42−2.55, $p < 0.001$).

Conclusion: In this study, patients with p-VT as the initial documented rhythm had significantly better outcomes than those with VF.

Keywords: Pulseless ventricular tachycardia, Ventricular fibrillation, Shockable rhythms

* Corresponding author at: Department of Cardiology, Fukuoka University School of Medicine, 7-45-1 Nanakuma, Jyonan-ku, Fukuoka 814-0180, Japan.
E-mail address: y.katoh0119@gmail.com (Y. Kato).

http://dx.doi.org/10.1016/j.resplu.2021.100107
Received 13 November 2020; Received in revised form 22 February 2021; Accepted 23 February 2021

Introduction

Out-of-hospital cardiac arrest (OHCA) is a high-priority public health problem in industrialized countries. Even though Kitamura et al. reported that neurologically favorable survival from OHCA in Japan improved to 2.8% because of intensive efforts, survival rates remain poor worldwide.[1–4] Systematic reviews have demonstrated that survival and neurological outcomes could be attributed to the quality of resuscitation, bystander cardiopulmonary resuscitation (CPR), time to CPR, return of spontaneous circulation (ROSC), use of an automated external defibrillator (AED), and the initial documented rhythm.[5–7] Of the initial documented rhythms, patients with shockable rhythms (i.e., pulseless ventricular tachycardia [p-VT] and ventricular fibrillation [VF]) were more likely to have a favorable outcome than those with non-shockable rhythms (i.e., pulseless electrical activity [PEA], and asystole).[8–10]

Without resuscitative interventions, OHCA with shockable rhythms subsequently deteriorate to non-shockable rhythms.[11] The period from cardiac arrest to death is less than 10 minutes (min). Such a progressive rhythms changes may be related to the previous finding that the first cardiac rhythm after cardiac arrest was VF in 15.0%, pulseless VT in 1.2%, PEA in 16.9%, asystole in 63.7%, in the time interval from collapse to initial recorded electrocardiogram (ECG) with a mean $\pm$ standard deviation (SD) of 14.9 $\pm$ 8.2 min.[12] Therefore, as considering time-dependent rhythms course, we hypothesized that clinical outcomes are different between p-VT and VF as the initial documented rhythms in OHCA patients.

The aim of this study was to evaluate the difference in clinical outcomes between p-VT and VF among patients with OHCA.

Methods

Study design

The All-Japan Utstein Registry of the Fire and Disaster Management Agency (FDMA) is a prospective, nationwide, population-based registry of OHCA based on the Utstein style, and has been described in detail previously.[13,14] Most patients with OHCA who are treated by emergency medical services (EMS) responders are transported to the nearest emergency hospital and registered in this All-Japan Utstein Registry. The EMS system in Japan, which includes training for EMS responders in emergency lifesaving techniques such as the insertion of an intravenous line and an adjunct airway (esophageal obturator airway or endotracheal intubation) and the use of a semi-AED for OHCA patients, has been previously described.[1,15] In Japan, the use of public AEDs for and by citizens has been legally permitted since July 2004. A subcommittee of resuscitation science in the Japanese Circulation Society was provided with the trial registry data after the prescribed governmental legal procedures were followed. The current study protocol was approved by the Ethics Committee of the National Cerebral and Cardiovascular Center (R19040).

Data collection

The collected data were as follows; sex, age, year, the initial documented rhythms, the time course of resuscitation (the time of collapse, initiation of bystander CPR, call for EMS service, scene, contact, initiation of CPR, defibrillation, epinephrine administration, hospital arrival, and ROSC), witnessed types (bystander-witnessed, EMS responder-witnessed, and unwitnessed), whether a bystander initiated CPR, whether the patient was intubated, whether epinephrine was administered, and whether ROSC was achieved before arrival at the hospital. All event times were synchronized by the dispatch center clock. The causes of arrest were classified as cardiogenic or non-cardiogenic (cerebrovascular disease; respiratory disease; malignant tumors; external factors, including drug overdose, drowning, trauma, hypothermia, anaphylaxis; or any other noncardiac factor), which was determined clinically by the physician in charge in collaboration with EMS personnel, and was confirmed by a staff member at the FDMA. The times of collapse and initiation of bystander CPR were obtained from interviews of the bystander by an EMS provider. A series of EMS times of call receipt, EMS arrival at the scene, contact with patients, initiation of CPR, defibrillation by EMS, ROSC, and hospital arrival were recorded with the clock of each EMS system. For all survivors, neurological outcomes were determined during 30-day follow-up interviews with the Cerebral Performance Category scale, as follows: Category 1 (good cerebral performance), Category 2 (moderate cerebral disability), Category 3 (severe cerebral disability), Category 4 (vegetative state), and Category 5 (death).[13] The FDMA have established the registry cohort and collected and verified a quality of the data. Collected data were integrated into the FDMA registry database server, and logically checked by the FDMA using an Utstein style online statistical survey system. If a study data form was incomplete, the FDMA returned it to the respective fire station for data completion.

Study population and outcomes

From the Utstein Registry between January 1, 2011, and December 31, 2015, we selected bystander-witnessed adult patients (aged $\geq$18 years) who were not treated with a public AED because of uncertainty regarding whether the shockable rhythm was p-VT or VF. The diagnosis of p-VT or VF was determined by an EMS responder or medical doctor on board using ECG monitor on an ambulance. In addition, we excluded patients who achieved ROSC before EMS arrival (patients who achieved ROSC for yourself without any treatment, or who achieved ROSC by bystander CPR alone) because the initial cardiac rhythm was unknown. The primary outcome was favorable 30-day neurological survival rates, defined as a Cerebral Performance Category 1 or 2. Additionally, the secondary outcomes were 30-day survival rates and prehospital ROSC rates.

Statistical analysis

Values are expressed as mean $\pm$ SD if the variable was normally distributed or median (interquartile range) if not, as determined by the Shapiro-Wilk test. Yearly trends in the proportion of favorable 30-day neurological outcome and bystander CPR in patients with p-VT or VF were analyzed using the Cochrane-Armitage test. Data were complete for all values except for defibrillation (n = 6), number of times of defibrillation (n = 512), advanced airway management (n = 243), epinephrine (n = 58), time from collapse to bystander CPR (n = 272), time from collapse to scene (n = 233), time from collapse to EMS contact (n = 133), time from collapse to CPR (n = 270), time from collapse to first defibrillation (n = 97), time from collapse to first ROSC (n = 62), time from collapse to epinephrine (n = 70), time from collapse to hospital arrival (n = 140), time from EMS contact to first defibrillation (n = 126), and time from first defibrillation to first ROSC (n = 226). We performed a pairwise deletion for handling the missing values. A two-tailed $p < 0.05$ was considered statistically significant. To determine the association of the initial documented rhythm with outcomes, we used a logistic regression model with adjustment for patient factors (age, sex, etiology of OHCA [cardiogenic or non-cardiogenic], and year) and prehospital care-related factors (bystander CPR status, time interval from collapse to EMS contact, time interval from EMS contact to first defibrillation, epinephrine administration, and advanced airway management) and calculated odds ratios (OR) and 95% confidence intervals (CI). Potential confounding factors based on previous studies were included in the multivariate analysis.[4–7] **Supplemental Tables S1 and S2** were analyzed by adding whether or not the patient underwent defibrillation. Additionally, we assessed the association between initial documented rhythms and the clinical outcomes adding witnessed status (i.e. bystander witnessed, EMS responder witnessed, and unwitnessed) as subgroup analysis (**Supplemental Fig. S2, Supplemental Tables S3,S4**). All statistical analyses were performed with JMP 12 (SAS Institute, Inc., Cary, NC, USA).

Results

Patient characteristics

During this 5-year period, a total of 629,471 OHCA patients were confirmed (Fig. 1). Of 207,045 bystander-witnessed cardiac arrest in adults, 155,832 had an information on the initial documented rhythm, 49,276 were treated with a public AED, 1937 underwent defibrillation (except for a public AED) or achieved ROSC before EMS arrival. With the exclusion of patients with non-shockable rhythms (n = 136,238), 19,594 patients were eligible for our analyses. The proportion of p-VT among these patients was 2.3% (n = 454), and VF was 97.7% (n = 19,140).

The baseline characteristics of patients with p-VT and VF are compared in Table 1. Compared to VF patients, p-VT patients were older (median, 78 versus 67 years), less likely to be male (59.5 versus 78.3%), less likely to have undergone defibrillation (48.3 versus 95.3%), and less likely to have a cardiogenic cause (62.8 versus 89.9%). Regarding the resuscitation-related time intervals, time from collapse to bystander CPR (median, 1 versus 2 min), time from collapse to EMS contact (median, 9 versus 9 min), and time from collapse to first ROSC (median, 16 versus 18 min) were shorter, whereas time from collapse to first defibrillation (median, 13 versus 12 min) and time from EMS contact to first defibrillation (median, 3 versus 2 min) were longer in p-VT patients compared to VF patients. In addition, time from first defibrillation to first ROSC was also shorter in patients with p-VT than those with VF (median, 3 versus 7 min). Of non-cardiogenic causes, p-VT patients were more likely to have a pulmonary disease or trauma than VF patients.

Yearly trends in the proportion of favorable 30-day neurological outcome in patients with p-VT or VF are shown in Fig. 2. While the proportion of favorable 30-day neurological outcome in VF increased significantly ($p < 0.001$ for trend), that in p-VT was not significant ($p = 0.158$ for trend). Additionally, the proportion of bystander CPR in VF increased significantly ($p < 0.001$ for trend), whereas that in p-VT was not significant ($p = 0.170$ for trend) (**Supplemental Fig. S1**).

Outcomes

p-VT patients had lower favorable 30-day neurological survival (15.2 versus 20.0%, $p = 0.009$) or 30-day survival rates (21.4 versus 30.0%, $p < 0.001$), while there was no significant difference in prehospital ROSC rates (32.4 versus 32.2%, $p = 0.94$) (Table 2).

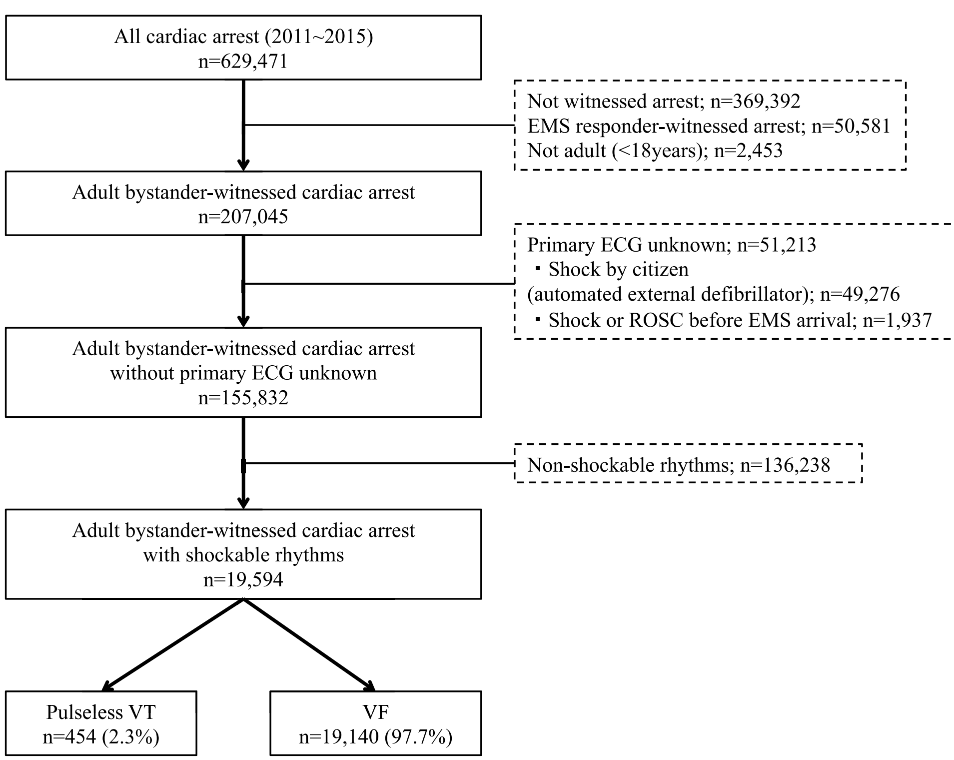

Fig. 1 – Study flow diagram. EMS, emergency medical services; ECG, electrocardiogram; ROSC, return of spontaneous circulation; VT, ventricular tachycardia; VF, ventricular fibrillation.

Table 1 – Baseline characteristics.

	p-VT (n = 454)	VF (n = 19,140)
Age (years), median (IQR)	78 (66–86)	67 (57–78)
Male, n (%)	270 (59.5%)	14,995 (78.3%)
Year		
2011	111 (24.5%)	4901 (25.6%)
2012	123 (27.1%)	4890 (25.5%)
2013	50 (11.0%)	3265 (17.1%)
2014	81 (17.8%)	3032 (15.8%)
2015	89 (19.6%)	3052 (16.0%)
Bystander CPR, n (%)	230 (50.7%)	10,489 (54.8%)
Defibrillation, n (%)	218 (48.3%)	18,228 (95.3%)
Number of times of defibrillation, n	1.6 ± 1.5	2.5 ± 1.8
Advanced airway management, n (%)	155 (34.7%)	7851 (41.5%)
Epinephrine, n (%)	103 (22.8%)	5534 (29.0%)
Etiology of cardiac arrest		
Cardiogenic, n (%)	285 (62.8%)	17,198 (89.9%)
Non-cardiogenic, n (%)	169 (37.2%)	1942 (10.1%)
Types of non-cardiogenic, n (%)		
Stroke	25 (14.8%)	316 (16.3%)
Pulmonary disease	44 (26.0%)	302 (15.5%)
Tumor	19 (11.3%)	179 (9.2%)
Trauma	34 (20.1%)	275 (14.2%)
Others	47 (27.8%)	870 (44.8%)
Time from collapse to bystander CPR, min (IQR)	1 (0–3)	2 (0–5)
Time from collapse to scene, min (IQR)	8 (5–11)	8 (6–11)
Time from collapse to EMS contact, min (IQR)	9 (6–12)	9 (7–13)
Time from collapse to CPR, min (IQR)	10 (6–13)	10 (7–13)
Time from collapse to 1st defibrillation, min (IQR)	13 (9–19)	12 (9–15)
Time from collapse to 1st ROSC, min (IQR)	16 (11–23)	18 (13–24)
Time from collapse to epinephrine, min (IQR)	23 (18–33)	23 (18–29)
Time from collapse to hospital arrival, min (IQR)	33 (26–41)	33 (27–41)
Time from EMS contact to 1st defibrillation, min (IQR)	3 (2–6)	2 (1–3)
Time from 1st defibrillation to 1st ROSC, min (IQR)	3 (1–7)	7 (3–12)

Data are presented as mean ± SD or median (interquartile range [IQR]) for continuous variables or the number (percent) of patients for category variables. VF, ventricular fibrillation; p-VT, pulseless ventricular tachycardia; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; ROSC, return of spontaneous circulation.

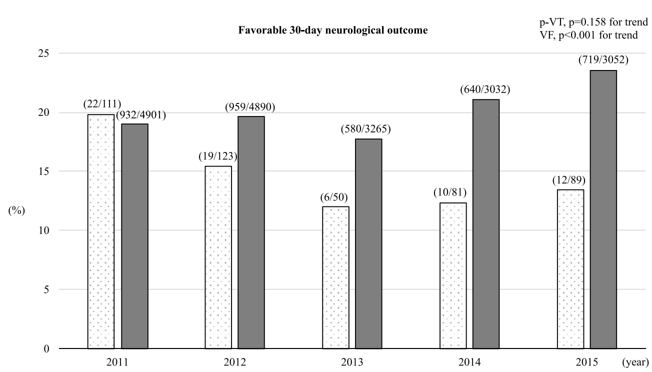

Fig. 2 – Temporal trends in the proportion of favorable 30-day neurological outcome in pulseless ventricular tachycardia (p-VT) and ventricular fibrillation (VF) among patients with bystander-witnessed out-of-hospital cardiac arrests (OHCA) in Japan between 2011 and 2015.

After adjustment for patient factors and prehospital care-related factors, p-VT was associated with high favorable 30-day neurological survival rates (adjusted OR, 1.85; 95% CI, 1.30–2.64, p = 0.001), 30-day survival rates (adjusted OR, 1.41; 95% CI, 1.03–1.95, p = 0.037), and prehospital ROSC rates (adjusted OR, 1.90; 95% CI, 1.42–2.55, p < 0.001) (Tables 3,4). The initial documented rhythm remained an independent factor for both the primary and secondary outcomes even when we considered whether or not the patient underwent defibrillation in the multivariate analysis (**Supplemental Tables S1,S2**).

Table 2 – Outcomes.

	p-VT (n = 454)	VF (n = 19,140)	p Value
Primary outcome			
Favorable 30-day neurological outcome, n (%)	69 (15.2%)	3830 (20.0%)	0.009
Secondary outcome			
30-day survival, n (%)	97 (21.4%)	5742 (30.0%)	<0.001
Prehospital ROSC, n (%)	147 (32.4%)	6166 (32.2%)	0.94

VF, ventricular fibrillation; p-VT, pulseless ventricular tachycardia; ROSC, return of spontaneous circulation.

Table 3 – Factors contributing to primary outcome.

Favorable 30-day neurological outcome	Univariate		Multivariate	
	Odds ratio (95%CI)	p Value	Odds ratio (95%CI)	p Value
Age, 1 year	0.97 (0.96–0.97)	<0.001	0.97 (0.97–0.97)	<0.001
Male	1.24 (1.13–1.35)	<0.001	0.91 (0.82–1.00)	0.053
Cardiogenic	2.96 (2.52–3.46)	<0.001	2.59 (2.17–3.10)	<0.001
Year	1.06 (1.03–1.08)	<0.001	1.05 (1.02–1.08)	0.002
Bystander CPR	1.65 (1.53–1.77)	<0.001	1.72 (1.58–1.87)	<0.001
Time from collapse to EMS contact, 1 min	0.93 (0.92–0.93)	<0.001	0.92 (0.91–0.93)	<0.001
Time from EMS contact to 1st defibrillation, 1 min	0.83 (0.81–0.85)	<0.001	0.85 (0.83–0.87)	<0.001
Epinephrine	0.30 (0.27–0.33)	<0.001	0.33 (0.30–0.37)	<0.001
Advanced airway management	0.34 (0.32–0.37)	<0.001	0.42 (0.39–0.46)	<0.001
p-VT	0.72 (0.55–0.93)	0.009	1.85 (1.30–2.64)	0.001

Logistic regression analysis, all variables in univariate analysis included in multivariate model. CPR, cardiopulmonary resuscitation; EMS, emergency medical services; p-VT, pulseless ventricular tachycardia.

Table 4 – Factors contributing to secondary outcomes.

30-day survival	Univariate		Multivariate	
	Odds ratio (95%CI)	p Value	Odds ratio (95%CI)	p Value
Age, 1 year	0.97 (0.97–0.97)	<0.001	0.97 (0.97–0.98)	<0.001
Male	1.18 (1.10–1.28)	<0.001	0.89 (0.82–0.97)	0.007
Cardiogenic	2.46 (2.18–2.78)	<0.001	2.08 (1.81–2.39)	<0.001
Year	1.06 (1.03–1.08)	<0.001	1.05 (1.02–1.07)	<0.001
Bystander CPR	1.42 (1.34–1.52)	<0.001	1.48 (1.38–1.59)	<0.001
Time from collapse to EMS contact, 1 min	0.93 (0.93–0.94)	<0.001	0.93 (0.92–0.94)	<0.001
Time from EMS contact to 1st defibrillation, 1 min	0.86 (0.84–0.88)	<0.001	0.88 (0.86–0.89)	<0.001
Epinephrine	0.44 (0.40–0.47)	<0.001	0.46 (0.42–0.50)	<0.001
Advanced airway management	0.49 (0.46–0.53)	<0.001	0.59 (0.55–0.63)	<0.001
p-VT	0.63 (0.51–0.80)	<0.001	1.41 (1.03–1.95)	0.037
Prehospital ROSC	**Univariate**		**Multivariate**	
	Odds ratio (95%CI)	p Value	Odds ratio (95%CI)	p Value
Age, 1 year	0.99 (0.99–0.99)	<0.001	0.99 (0.99–0.99)	<0.001
Male	0.99 (0.92–1.06)	0.79	0.84 (0.77–0.91)	<0.001
Cardiogenic	1.83 (1.64–2.04)	<0.001	1.51 (1.34–1.71)	<0.001
Year	1.05 (1.03–1.08)	<0.001	1.05 (1.02–1.07)	<0.001
Bystander CPR	1.34 (1.27–1.43)	<0.001	1.38 (1.30–1.48)	<0.001
Time from collapse to EMS contact, 1 min	0.95 (0.94–0.95)	<0.001	0.94 (0.94–0.95)	<0.001
Time from EMS contact to 1st defibrillation, 1 min	0.90 (0.88–0.91)	<0.001	0.91 (0.90–0.93)	<0.001
Epinephrine	0.68 (0.64–0.73)	<0.001	0.77 (0.72–0.83)	<0.001
Advanced airway management	0.52 (0.48–0.55)	<0.001	0.56 (0.52–0.60)	<0.001
p-VT	1.01 (0.83–1.23)	0.941	1.90 (1.42–2.55)	<0.001

Logistic regression analysis, all variables in univariate analysis included in multivariate model. ROSC, return of spontaneous circulation; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; p-VT, pulseless ventricular tachycardia.

The subgroup analysis which assessed adding witnessed status in patients with shockable rhythms are shown in **Supplemental Fig. S2 and Supplemental Tables S3,S4**. After adjustment for covariates, EMS responder-witnessed had the most favorable primary and secondary outcomes than other two witnessed types. Subsequently, bystander-witnessed had better favorable primary and secondary outcomes than unwitnessed type. p-VT also remained an independent factor for both the primary and secondary outcomes in a subgroup analysis.

Discussion

In this study using a large, prospective nationwide registry of OHCA, we demonstrated that p-VT was associated with better favorable 30-day neurological survival rates, 30-day survival rates, and prehospital ROSC rates after adjusting for patient factors and prehospital care-related factors.

Meaney et al. reported that clinical outcomes were comparable between p-VT and VF as the initial documented cardiac rhythms.[16] There were no significant associations with the initial documented rhythms and 30-day neurological outcomes (p-VT versus VF; 31.2% versus 31.6%, adjusting OR = 1.07, 95%CI = 0.93−1.22), ROSC rates (p-VT versus VF; 67.5% vs 62.6%, adjusting OR = 0.88, 95% CI = 0.78−1.00), and 24-hour survival rates (p-VT versus VF; 53.3% vs 50.6%, adjusting OR = 1.01, 95%CI = 0.90−1.13). However, their report focused on the outcomes of in-hospital cardiac arrest (IHCA). Therefore, patient background, resuscitation-related time intervals, and adjusting variables were different from those in our study. Compared to patients with OHCA, most patients with IHCA can be underwent CPR as soon as possible under monitoring by electrocardiogram, while they are acutely ill and have other acute comorbidities. In OHCA, the importance of improvements in “chain of survival”, shortening resuscitation-related time intervals, has been accepted widely.[17,18] Previous study reported that the differences in both resuscitation efforts and time interval to start treatment between OHCA and IHCA have influenced the neurological outcome.[19] As “chain of survival”, as well as resuscitation efforts, yearly trends in the proportion of bystander CPR in VF increased, which contributed to increased favorable 30-day neurological outcome in VF. It is unknown why it was not in patients with p-VT as a shockable rhythm in OHCA.

In this study, time from collapse to bystander CPR and time from collapse to EMS contact were shorter in patients with p-VT than those with VF. The superiority of these resuscitation-related time intervals may contribute the favorable outcomes in patients with p-VT. In addition, VT can initially keep hemodynamics with producing a perfusing rhythm, whereas in VF the heart is unable to function as a pump. Sustaining of VT lead to hemodynamic instability and conversion to VF,[20,21] resulting in a long-time interval from collapse to EMS contact in VF patients. Furthermore, time from defibrillation to ROSC was shorter in p-VT, suggesting that p-VT may respond better to the initial defibrillation than VF. Many factors such as time from collapse to defibrillation, the causes of cardiac arrest, and physiologies might be complicatedly associated the response to the defibrillation. Regarding the causes of cardiac arrest, p-VT patients had more non-cardiogenic causes than VF patients, contributing a low defibrillation rate in p-VT patients. Only 48.3% of p-VT underwent defibrillation, whereas 95.3% of VF was. While the reason why a low defibrillation rate in p-VT patients despite a shockable rhythm is unknown, the factors such as a situation and a location of cardiac arrest which we could not collect may have influenced. Note that, among patients with p-VT, patients who underwent defibrillation had a higher ROSC rate than patients who did not (43.6 versus 21.9%, $p < 0.001$), and patients who achieved ROSC had shorter time from collapse to first defibrillation than patients who did not (11 versus 14 min, $p = 0.02$). Therefore, an earlier defibrillation is reasonable regardless of a low defibrillation rate in p-VT patients in this study.

Our study has several limitations that need to be taken into account. First, there were no details on the potential variability in post-arrest care (hemodynamic support, induced hypothermia, and coronary interventional therapies), although the development of these treatments could also explain the improved outcomes. Second, this study had only a 5-year observation period. Therefore, long-term observation is needed to assess the differences in outcomes between p-VT and VF. We enrolled patients with OHCA between January 2011 and December 2015, because the 2010 AHA Guidelines for CPR and ECC recommended a change in the basic life support (BLS) sequence from A-B-C (Airway, Breathing, Chest compressions) to C-A-B (Chest compressions, Airway, Breathing) for patients with OHCA.[22] Therefore, we did not examine the data before 2010, which marks a change in prehospital care-related factors. Third, the diagnosis of arrhythmias on OHCA was mostly dependent on EMS responders. It may have been difficult to distinguish between polymorphic VT as well as Torsades de Pointes or VF, or between slow p-VT and PEA in the electrocardiogram. Presumably, patients who were identified as VF may include polymorphic VT. Furthermore, the reliability or validity of detecting p-VT is controversial, because whether pulseless or not is subjective of an EMS responder. In addition, dispatcher-assisted CPR as well as the quality of resuscitation affects the neurological outcome.[23] Although the training and experience of EMS responders influence clinical outcomes, no information about these points was available. Fourth, the “true” initial cardiac rhythm is unknown. The time from collapse to defibrillation was longer in patients after we excluded those in whom a public AED was used. Therefore, the initial cardiac rhythm might change during CPA; VT may convert to VF or asystole. Moreover, survival outcomes were worse following PEA/asystole with subsequent VT/VF (VT or VF occurring during resuscitation for PEA or asystole) compared to PEA/asystole without subsequent VT/VF.[17,24] We did not assess rhythm conversion, which may affect the outcome. Additionally, the reliability and validity of time points obtained by interviews with bystanders were uncertain, while we focused on the time course of resuscitation. Finally, in all epidemiological studies, data integrity, validity, and ascertainment bias are potential limitations. The use of uniform data collection, a large sample size, and a population-based design to cover all known OHCAs in Japan were intended to minimize these potential sources of bias.

Conclusions

In this nationwide, population-based study of OHCA, p-VT as the initial documented rhythm was associated with higher favorable 30-day neurological survival rates, 30-day survival rates, and prehospital ROSC rates than VF.

Sources of funding

None.

Conflict of interest

Dr Miura reported receiving remunerations from Daiichi Sankyo Co. Ltd., Takeda Pharmaceutical Co., Ltd., Boehringer Ingelheim, Otsuka Pharmaceutical Co., Ltd., and Bayer Yakuhin, Ltd., research funding from Daiichi Sankyo Co. Ltd., Takeda Pharmaceutical Co. Ltd., Astellas Pharma Inc., and Bayer Yakuhin, Ltd., and scholarship funds from Alfresa Corporation. Dr Tsutsui reported receiving research funding from Mitsubishi Tanabe Pharma Corporation, Japan Tobacco Inc., Boehringer Ingelheim, OMRON HEALTHCARE Co. Ltd., Daiichi Sankyo Co. Ltd., Actelion Pharmaceuticals Ltd, Actelion Ltd., IQVIA Services Japan K.K., and scholarship funds from Daiichi Sankyo Co. Ltd., TEIJIN PHARMA Ltd., Mitsubishi Tanabe Pharma Corporation, and Merck Sharp & Dohme (MSD) K.K. The other authors report no conflicts.

Acknowledgements

We thank all the EMS personnel, the staff of the Fire and Disaster Management Agency, and the staff of the Institute for Fire Safety and Disaster Preparedness of Japan for their cooperation in establishing and maintaining the Utstein database.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resplu.2021.100107.

REFERENCES

1. 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.
2. Xu F, Zhang Y, Chen Y. Cardiopulmonary resuscitation training in China: current situation and future development. JAMA Cardiol 2017;2:469–70.
3. Chan PS, McNally B, Tang F, Kellermann A, CARES Surveillance Group. Recent trends in survival from out-of-hospital cardiac arrest in the United States. Circulation 2014;130:1876–82.
4. 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.
5. Soar J, Maconochie I, Wyckoff MH, et al. 2019 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Resuscitation 2019;145:95–150.
6. Hallstrom AP, Ornato JP, Weisfeldt M, et al. Public-access defibrillation and survival after out-of-hospital cardiac arrest. N Engl J Med 2004;351:637–46.
7. Yan S, Gan Y, Jiang N, et al. The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis. Critical Care 2020;24:61.
8. Nadkarni VM, Larkin GL, Peberdy MA, et al. First documented rhythm and clinical outcome from in-hospital cardiac arrest among children and adults. JAMA 2006;295:50–7.
9. Daya MR, Schmicker RH, Zive DM, et al. Out-of-hospital cardiac arrest survival improving over time: results from the resuscitation outcomes consortium (ROC). Resuscitation 2015;91:108–15.
10. Peberdy MA, Kaye W, Ornato JP, et al. Cardiopulmonary resuscitation of adults in the hospital: a report of 14720 cardiac arrests from the National Registry of Cardiopulmonary Resuscitation. Resuscitation 2003;58:297–308.
11. Callans DJ. Out-of-hospital cardiac arrest—the solution is shocking. N Engl J Med 2004;351:632–4.
12. SOS-KANTO Committee. 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.
13. Cummins RO, Chamberlain DA, Abramson NS, et al. Recommended guideline for uniform reporting of data from out-of-hospital cardiac arrest: the Utstein style: a statement for health professionals from a task force of the American Heart Association, the European Resuscitation Council, the Heart and Stroke Foundation of Canada, and the Australian Resuscitation Council. Circulation 1991;84:960–75.
14. Jacobs I, Nadkarni V, Bahr J, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update and simplification of the Utstein templates for resus-citation 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.
15. Kitamura T, Iwami T, Kawamura T, et al. Nationwide public access defibrillation in Japan. N Engl J Med 2010;362:994–1004.
16. Meaney PA, Nadkarni VM, Kern KB, Indik JH, Halperin HR, Berg RA. Rhythms and outcomes of adult in-hospital cardiac arrest. Crit Care Med 2010;38:101–8.
17. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the “chain of survival” concept. Circulation 1991;83:1832–47.
18. 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.
19. Herlitz J, Bång A, Ekström L, et al. A comparison between patients suffering in-hospital and out-of-hospital cardiac arrest in terms of treatment and outcome. J Intern Med 2000;248:53–60.
20. Huikuri HV, Castellanos A, Myerburg RJ. Sudden death due to cardiac arrhythmias. N Engl J Med 2001;345:1473–82.
21. Samie FH, Jalife J. Mechanisms underlying ventricular tachycardia and its transition to ventricular fibrillation in the structurally normal heart. Cardiovasc Res 2001;50:242–50.
22. Berg RA, Hemphill R, Abella BS, et al. Part 5: adult basic life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2010;122:S685–705.
23. Nikolaou N, Dainty KN, Couper K, Morley P, Tijssen J, Vaillancourt C, International Liaison Committee on Resuscitation’s (ILCOR) Basic Life Support and Pediatric Task Forces. A systematic review and meta-analysis of the effect of dispatcher-assisted CPR on outcomes from sudden cardiac arrest in adults and children. Resuscitation 2019;138:82–105.
24. Hallstrom A, Rea TD, Mosesso Jr VN, et al. The relationship between shocks and survival in out-of-hospital cardiac arrest patients initially found in PEA or asystole. Resuscitation 2007;74:418–26.