**Title**

Shortening of CPR time before the defibrillation worsens the outcome in out-of-hospital VF patients

**Authors**

Mineji Hayakawa, MD [a] Satoshi Gando, MD, PhD [a]
Hiroyuki Okamoto, MD [b] Yasufumi Asai, MD, PhD [b]
Shinji Uegaki, MD [c] Hiroshi Makise, MD [c]

[a] *Emergency and Critical Care Center, Hokkaido University Hospital*
[b] *Department of Traumatology and Critical Care Medicine, Sapporo Medical University Hospital*
[c] *Emergency and Critical Care Center, Sapporo City General Hospital*

**Conflict of interest**

This work was supported by a research grant from Foundation for Ambulance Service Development in Japan.

**Corresponding author**

Mineji Hayakawa, MD
Emergency and Critical Care Center, Hokkaido University Hospital,
N14W5, Kita-ku, Sapporo 060-8648 Japan
TEL +81-11-706-7377 / FAX +81-11-706-7378
e-mail mineji@dream.com

**KEY WORDS**

Cardiac arrest
Defibrillation
Out-of-hospital
Utstein template
Ventricular fibrillation

**Abstract**

**Objective:** To investigate the influence of cardiopulmonary resuscitation (CPR) time before the first defibrillation.

**Methods:** The present study retrospectively analyzed the Utstein template records from April 1, 2002 to June 30, 2005. Patients who had out-of-hospital witnessed cardiac arrest caused by cardiac disease and who presented with ventricular fibrillation (VF) as the initial cardiac rhythm were included in the study. Before April 1, 2003, the emergency medical technician (EMT) needed to obtain telephone permission before attempting defibrillation, and CPR was continued until permission was received (CPR first). On and after April 1, 2003, the EMT was immediately able to attempt a defibrillation without obtaining permission (Shock first).

**Results:** In 143 patients who had out-of-hospital witnessed VF, 43 patients and 100 patients were treated with the CPR first strategy and the Shock first strategy, respectively. The duration of CPR before the first defibrillation was longer in the CPR first group than that in the Shock first group. The CPR first group showed a higher rate of favorable neurological outcome 30 days after (28% vs. 14%, $P$ = .048) and 1 year after cardiac arrest (26% vs. 11%, $P$ = .033) than those of the Shock first group. In the patients with witnessed VF, a stepwise multiple

logistic-regression analysis showed the CPR first strategy to improve the neurological outcome.

**Conclusions:** In patients with out-of-hospital witnessed VF, sufficient CPR before the first defibrillation is considered to improve the neurological outcome in comparison to the performance of immediate defibrillation.

## 1. Introduction

Early defibrillation is an important procedure in patients with ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT). In patients with out-of-hospital cardiac arrest, several reports indicated that defibrillation improved the survival rate when the time from collapse to defibrillation was within a few minutes [1-4]. The survival rate may decrease by approximately 10% for every minute in patients with VF in the first several minutes after cardiac arrest [5,6]. However, patients attended by rescuers within a few minutes of cardiac arrest are in the minority, and a far greater number of patients therefore experience a longer period prior to the start of initial treatment [7].

Recently, several reports have indicated the importance of cardiopulmonary resuscitation (CPR) before defibrillation in out-of-hospital VF [8,9]. Cobb *et al.* [8] and Wik *et al.* [9] showed the advantage of several minutes of CPR before defibrillation in patients with VF and with response intervals longer than 4 or 5 minutes. CPR before defibrillation was reported to improve myocardial readiness for defibrillation [10] although myocardial adenosine triphosphate content diminished significantly during untreated prolonged VF [11].

In Japan, emergency medical technicians (EMTs) have been allowed to attempt defibrillation by using an automated external defibrillator for a patient

with out-of-hospital VF or pulseless VT after 1991. Because of the requirement for telephone permission by a medical doctor to attempt defibrillation, the EMTs had continued CPR until permission was received on and after April 1, 2003, EMTs officially obtained permission to perform early defibrillation for a patient with out-of-hospital VF or pulseless VT without a doctor's permission.

This report compared the outcome of patients whose initial rhythm was VF during 2 continuous periods to investigate the influence of CPR time before the first defibrillation for patients with out-of-hospital bystander-witnessed VF.

## 2. Methods

### 2. 1. Patients

Sapporo city started monitoring out-of-hospital cardiac arrests according to the Utstein template [12] on April 1, 2002. The present study retrospectively analyzed the Utstein template [12] records from April 1, 2002, to June 30, 2005. The patients who had out-of-hospital bystander-witnessed cardiac arrest caused by cardiac disease and who presented with VF as the initial cardiac rhythm at the arrival of EMTs were included in the study. Patients who had cardiac arrest after the arrival of EMTs were excluded. Cardiac arrest was defined as the cessation of cardiac mechanical activity, which was manifested as

unresponsiveness, apnea, and absence of a pulse. All events were measured by the dispatch center or the automated defibrillator clock and recorded.

**2. 2. Treatment procedures**

Each patient managed by an ambulance with three EMTs. When cardiac arrest was detected in the patient, chest compression and ventilation by a bag valve mask was immediately started by two EMTs. Basic life support was provided according to the Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care [13]. The other EMT applied a monophasic automated defibrillator (Heart Start 3000, Laerdal Medical Japan K.K., Tokyo, Japan) to the patient. Before April 1, 2003, the EMT needed to obtain telephone permission from a medical doctor before attempting defibrillation, and CPR (chest compression and ventilation) was continued until permission was received. This strategy was defined as the CPR first strategy. On and after April 1, 2003, the EMT was immediately able to attempt a defibrillation without obtaining permission, if necessary. This strategy was defined as the Shock first strategy.

Other treatment procedures by EMTs were the same as those used in the CPR first strategy and the Shock first strategy except for CPR time before the first defibrillation. In the patients with VF, the first defibrillating shock of 200 J

was given. If unsuccessful, defibrillation was repeated once with 300J, and if necessary, once more with 360J. An EMT inserted an esophageal obturator airway (EOA) as soon as possible without disturbing the electrocardiographic analysis and defibrillation. EMTs were not permitted to use a tracheal tube or any drugs during the study period in Japan. After the attempt of defibrillation and the insertion of EOA, the EMTs transferred the patients to an emergency hospital performing CPR regardless of the return of spontaneous circulation. The call receipt, ambulance stop, and start of CPR were all measured by the dispatch center clock. The time of the first defibrillation was recorded automatically by the automated defibrillator. During the study period, the general public was not permitted to use an automated defibrillator in Japan.

**2. 3. Outcome investigation**

The study primary endpoints were favorable neurological outcome 30 days and 1 year after cardiac arrest. The favorable neurological outcome was defined as 1 (good performance) or 2 (moderate disability) of cerebral performance category. [12] The secondary endpoints were survival of 30 days and 1 year after cardiac arrest. These were investigated by telephone interviews to family or medical staff members.

## 2. 4. Statistical analysis

The SPSS 15.0J statistical software package (SPSS Inc., Chicago, Illinois) was used for all statistical calculation analyses. Comparisons between the groups were made using unpaired Student's *t*-test and the Chi-square test. A stepwise multiple logistic-regression analysis was used to assess the relationship between the favorable neurological outcome 1 year after cardiac arrest and variables as follows; age, gender, arrests witnessed by bystanders, bystander performed CPR, difference of CPR strategy, and time intervals related the Utstein template. [12] A $P$ value of $< .05$ was considered to be statistically significant. Unless otherwise indicated, all data were expressed as the means ± SD.

## 3. Results

During the study period, 143 patients with out-of-hospital bystander-witnessed cardiac arrest had VF when an ambulance arrived at the scene. Forty-three patients and 100 patients were treated with the CPR first strategy and the Shock first strategy, respectively. The characteristics of the patients were presented in Table 1. The CPR time before the first defibrillation were statistically longer in the CPR first group than those in the Shock first group

(3.7 ± 2.2 vs. 2.3 ± 1.3 min, $P < .001$).

The neurological outcomes of the patients were presented on Fig. 1. There were statistically significant differences between the CPR first group and the Shock first group in the favorable neurological outcome 30 days after [(28%, 14/43) vs. (14%, 14/100), $P = .048$] and 1 year after cardiac arrest [(26%, 11/43) vs. (11%, 11/97), $P = .033$]. In the Shock first group, three patients were lost during the 1-year follow-up. There were no differences between the CPR first group and the Shock first group in the 30-day-survival rate [(37%, 16/43) vs. (38%, 38/100), $P = .929$] and 1-year survival rate [(30%, 13/43) vs. (23%, 22/97), $P = .341$]. Other outcomes of the patients were presented in Table 2.

In the VF patients, a stepwise multiple logistic-regression analysis showed the odds ratios and 95% confidence intervals (CI) for a favorable neurological outcome (Fig. 2). The CPR first strategy (the odds ratio, 2.84; 95% CI, 1.10-7.33, $P = .032$) improved the proportions of favorable neurological outcome. The Shock first strategy (the odds ratio, .35; 95% CI, .14-.91, $P = .032$) worsened the proportions of favorable neurological outcome. In addition, an increase in the patient's age (odds ratio, .97; 95% CI, .94-1.00; $P = .047$) negatively influenced the rate of a favorable neurological outcome.

## 4. Discussion

The present study showed an association between the Shock first strategy and a worse neurological outcome in patients with out-of-hospital bystander-witnessed VF. This finding suggests an importance of CPR before defibrillation in out-of-hospital VF. These data were consistent with the results of the two previous studies [8,9].

Weisfeldt and Becker [7] proposed a three–phase time sensitive model of resuscitation after cardiac arrest. During approximately 4 minutes after cardiac arrest, early defibrillation is very effective (electrical phase) [7]. To achieve early defibrillation in the electrical phase, non-EMTs (e.g. casino officers [1], flight airline officers [2], police rescuers [3], and general public [4]) have to perform the defibrillation with an automated external defibrillator. However, few patients with out-of hospital VF receive defibrillation in the electrical phase [7]. The majority of patients with out-of hospital VF are treated by EMTs during the circulatory phase [7]. In fact, more than 90% of the patients with out-of-hospital VF waited more than 5 minutes from receiving the emergency call until the start CPR by EMTs in the present study. During untreated prolonged VF, a decrease of myocardial adenosine triphosphate content makes it difficult to restore the spontaneous circulation by defibrillation [11]. Eftestol *et al*. [10] indicated that the CPR before defibrillation improved the myocardial readiness for defibrillation in patients with

untreated prolonged VF. In the present study and investigations of Cobb *et al* [8] and Wik *et al* [9], the CPR first strategy improved the outcome of the patients in the circulatory phase (e.g. patients with out-of-hospital VF).

Several experimental studies reported that CPR before defibrillation had various benefits [14-16]. In swine with 8 minutes of untreated VF, CPR for 90 seconds followed by defibrillation shock resulted in physiological benefits and a superior response to initial defibrillation in comparison with immediate defibrillation [14]. In a dog model, a brief CPR before defibrillation improved the resuscitation outcome from prolonged VF [15]. Kolarova *et al* [16] showed that the rate of restored spontaneous circulation increased in proportion to the duration of CPR before defibrillation. In this study, less than 2 minutes of CPR before defibrillation did not improve the rate of restored spontaneous circulation [16]. This result also indicates that CPR may have to be performed for more than 3 minutes before defibrillation shock.

Wik *et al.* [9] also showed that 3 minutes of CPR before defibrillation improved the outcome in patients with out-of-hospital prolonged VF. In the present study, more than 90% of the patients with out-of-hospital VF took more than 5 minutes from call receipt to the start of CPR by EMTs. Furthermore, CPR prior to defibrillation was performed for 3.7 ± 2.2 minutes in the CPR first strategy. For these reason, the CPR first group may have better a neurological outcome

than that of the Shock first group. Jacobs *et al.* [17] showed the CPR before defibrillation did not improve the overall survival in patients suffering out-of-hospital VF. In their study [17], CPR before defibrillation was performed for 90 seconds, the same as described in the report of Cobb *et al.* [8] Eftestol *et al*. [10] indicated that the VF waveform improved with CPR and these changes appeared to be more prominent for CPR lasting more than 3 minutes. These clinical studies and the current results suggest that more than 3 minutes of CPR before defibrillation may improve the outcome of patients with prolonged VF.

In the present study, a multiple logistic regression analysis suggests an association between the CPR first strategy and the improved neurological outcome of patients with bystander-witnessed VF. However, the duration of CPR before defibrillation did not affect the neurological outcome. An excessive amount of CPR before defibrillation may worsen the neurological outcome, regardless of the importance of CPR before defibrillation in out-of-hospital prolonged VF. However, the study did not clearly identify an ideal or appropriate duration of CPR before defibrillation.

In previous studies performed by Cobb *et al*. [8] and Wik *et al*. [9], the CPR first strategy improved the neurological outcome and survival rate. The present study showed that the CPR first strategy improves the neurological outcome but not the survival rate. The survival rate at hospital discharge in this

study, which was 37%, was much higher than those of previous studies (26% in the Cobb *et al.* study [8], 14% in the Wik *et al*. study [9]). In the present study, 10% of the patients were in a vegetative state at the time of hospital discharge, which was a higher rate than the approximately 1% observed in previous studies [8,9]. At 1 year after cardiac arrest, 5% of the patients with out-of-hospital VF in the present study survived in a vegetative state. These results may explain the reason why this study did not show any improvement in the survival rate.

### 4.1. Conclusions

Our findings support previous experimental and clinical studies. A brief period of CPR before defibrillation should therefore be considered to improve the neurological outcome in patients with out-of-hospital bystander-witnessed VF.

## References


[1] Valenzuela TD, Roe DJ, Nichol G, et al. Outcomes of rapid defibrillation by security officers after cardiac arrest in casinos. N Engl J Med 2000; 343: 1206-9.

[2] Page RL, Joglar JA, Kowal RC, et al. Use of automated external defibrillators by a U.S. airline. N Engl J Med 2000; 343: 1210-6.

[3] Myerburg RJ, Fenster J, Velez M, et al. Impact of community-wide police car deployment of automated external defibrillators on survival from out-of-hospital cardiac arrest. Circulation 2002; 106: 1058-64.

[4] Caffrey SL, Willoughby PJ, Pepe PE, et al. Public use of automated external defibrillators. N Engl J Med 2002; 347: 1242-7.

[5] Larsen MP, Eisenberg MS, Cummins RO, et al. Predicting survival from out-of-hospital cardiac arrest: a graphic model. Ann Emerg Med 1993; 22: 1652-8.

[6] Valenzuela TD, Roe DJ, Cretin S, et al. Estimating effectiveness of cardiac arrest interventions: a logistic regression survival model. Circulation 1997; 96: 3308-13.

[7] Weisfeldt ML, Becker LB. Resuscitation after cardiac arrest: a 3-phase time-sensitive model. JAMA 2002; 288: 3035-8.

[8] Cobb LA, Fahrenbruch CE, Walsh TR, et al. Influence of cardiopulmonary resuscitation prior to defibrillation in patients with out-of-hospital ventricular fibrillation. JAMA 1999; 281: 1182-8.

[9] Wik L, Hansen TB, Fylling F, et al. Delaying defibrillation to give basic cardiopulmonary resuscitation to patients with out-of-hospital ventricular fibrillation: a randomized trial. JAMA 2003; 289: 1389-95.

[10] Eftestol T, Wik L, Sunde K, et al. Effects of cardiopulmonary resuscitation on predictors of ventricular fibrillation defibrillation success during out-of-hospital cardiac arrest. Circulation 2004; 110: 10-5.

[11] Kern KB, Garewal HS, Sanders AB, et al. Depletion of myocardial adenosine triphosphate during prolonged untreated ventricular fibrillation: effect on defibrillation success. Resuscitation 1990; 20: 221-9.

[12] Cummins RO, Chamberlain DA, Abramson NS, et al. Recommended guidelines 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.

[13] Part 3: adult basic life support. European Resuscitation Council. Resuscitation 2000; 46: 29-71.

[14] Berg RA, Hilwig RW, Ewy GA, et al. Precountershock cardiopulmonary resuscitation improves initial response to defibrillation from prolonged ventricular fibrillation: a randomized, controlled swine study. Crit Care Med 2004; 32: 1352-7.

[15] Niemann JT, Cairns CB, Sharma J, et al. Treatment of prolonged ventricular fibrillation. Immediate countershock versus high-dose epinephrine and CPR preceding countershock. Circulation 1992; 85: 281-7.

[16] Kolarova J, Ayoub IM, Yi Z, et al. Optimal timing for electrical defibrillation after prolonged untreated ventricular fibrillation. Crit Care Med 2003; 31: 2022-8.

[17] Jacobs IG, Finn JC, Oxer HF, et al. CPR before defibrillation in out-of-hospital cardiac arrest: a randomized trial. Emerg Med Australas 2005; 17: 39-45.

## Figure legends

Fig. 1 The neurological outcome of the CPR first group (open bar) and the Shock first group (shadowed bars). There were statistical significances between the CPR first group and the Shock first group in the favorable neurological outcome 30 days after (28% vs. 14%) and 1 year after cardiac arrest (26% vs. 11%).

Fig. 2 The odds ratios and 95% confidence intervals (CI) for a favorable neurological outcome based on a stepwise multiple logistic-regression analysis. The CPR first strategy ($P$ = .032) improved the neurological outcome.

**Table 1** Baseline characteristics of the patients

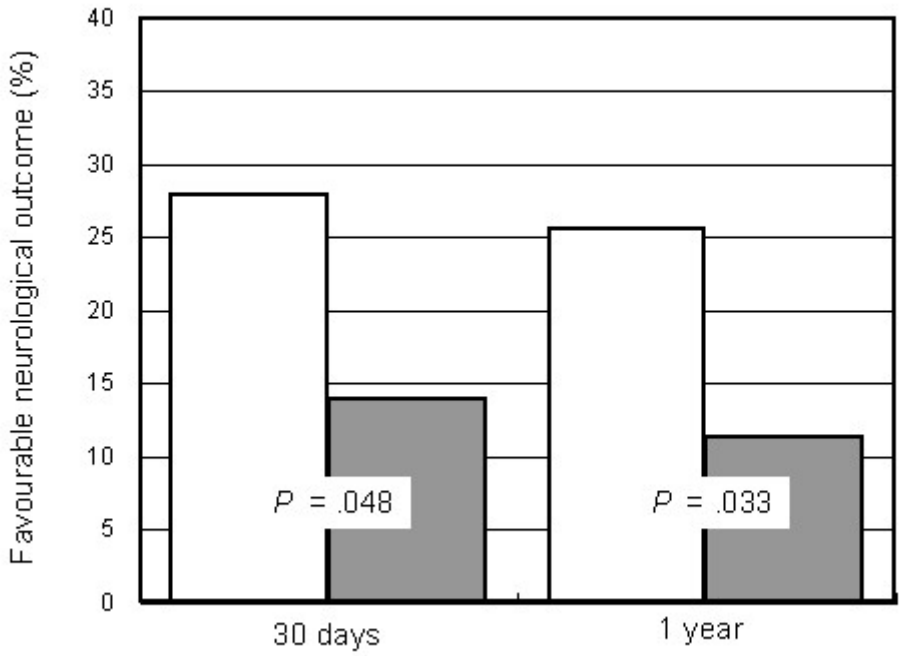
| Characteristics | CPR First (n=43) | Shock First (n=100) | *P* value |
|---|---|---|---|
| Age (year) | 61 ± 16 | 60 ± 15 | .879 |
| Male (n [%]) | 41 (95) | 89 (89) | .226 |
| Bystander performed CPR (n [%]) | 15 (35) | 39 (39) | .642 |
| From call receipt to ambulance stop (min) | 5.7 ± 2.2 | 5.7 ± 1.8 | .867 |
| From call receipt to CPR by EMTs (min) | 6.8 ± 2.4 | 7.1 ± 1.9 | .490 |
| CPR time by EMTs before the first shock attempt (min) | 3.7 ± 2.2 | 2.3 ± 1.3 | < .001 |

Data are the mean ± SD where appropriate. CPR cardiopulmonary resuscitation, EMT emergency medical technician.

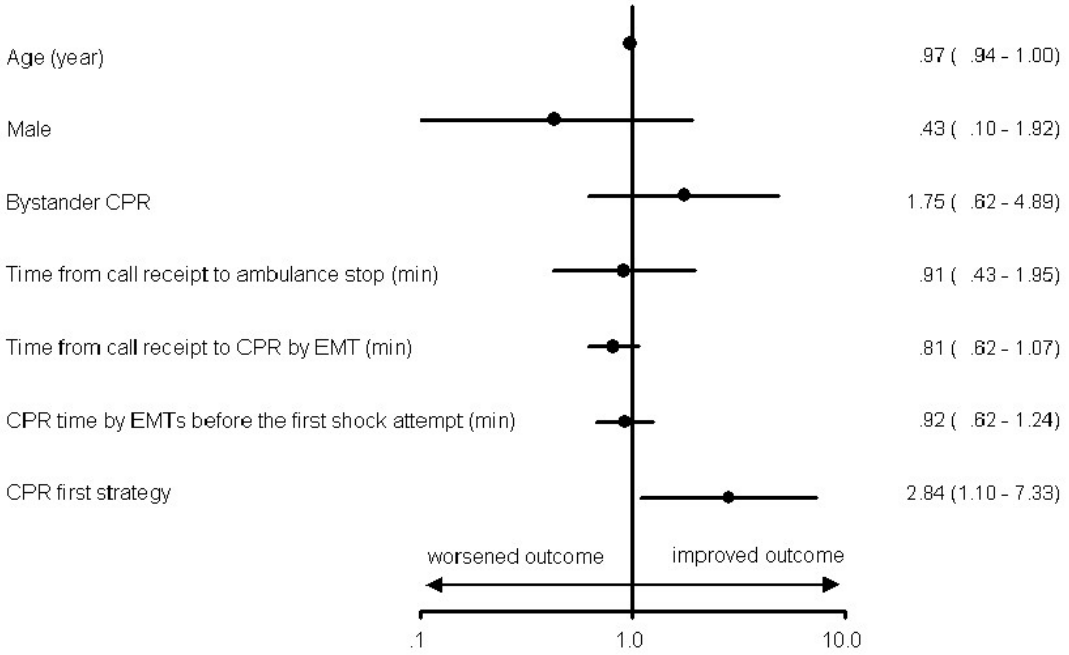
**Table 2** Outcomes of the patients

| Outcomes | CPR First (n=43) | Shock First (n=100) | *P* value |
|---|---|---|---|
| ROSC (n [%]) | 30 (70%) | 65 (65%) | .717 |
| Admission (n [%]) | 30 (70%) | 65 (65%) | .717 |
| Survival to discharge (n [%]) | 16 (37%) | 40 (40%) | .898 |
| Survival to 30 days (n [%]) | 16 (37%) | 38 (38%) | .929 |
| Favorable neurological sate 30 days after (n [%]) | 12 (28%) | 14 (14%) | .048 |
| Survival to 1 year (n [%]) | 13 (30%) | 22 (23%) | .341 |
| Favorable neurological staet 1 year after (n [%]) | 11 (26%) | 11 (11%) | .033 |

In the Shock first group, 3 patients were lost to the 1-year-after follow-up. ROSC return of spontaneous circulation.




Shortening of CPR worsens outcome of VF patients




Shortening of CPR worsens outcome of VF patients