Outcomes of Pediatric Out-of-Hospital Cardiac Arrest
– Lessons Learned and Future Directions –

Shigetoyo Kogaki, MD

Out-of-hospital cardiac arrest (OHCA) is a leading cause of death worldwide and an emotionally charged event that has a major effect on the family and communities, particularly when it affects an infant or a child who is presumed to be healthy. Sasson et al have conducted a large systematic review and meta-analysis to assess the associations between key clinical predictors (bystander witness, emergency medical service (EMS) witness, bystander cardiopulmonary resuscitation (CPR), shockable cardiac rhythm, and return of spontaneous circulation) and survival from OHCA using data from 49 studies from all over the world. They found that OHCA victims who receive CPR from a bystander or an EMS provider, and those who are found in ventricular fibrillation (VF) or ventricular tachycardia (VT), are much more likely to survive than those who do not. Moreover, they found that the strength of association between VF/VT and survival was greatest in locations in which a defibrillator is available at public sites. These associations were clinically important, but their analyses have been conducted under exclusion of any studies that contained more than 20% pediatric patients (age <18 years).

In this issue of the Journal, Mitani et al report a nationwide hospital-based survey of elementary and middle-school students in Japan in the era of public access defibrillation (PAD). They found that school-aged children after OHCA were more likely to be resuscitated and defibrillated by bystanders (especially school teachers) and had a better outcome in school than out of school. They emphasize that the study results could be relevant to the efficient placement of AED and the focused education of CPR with AED in schools.

The worldwide incidence of pediatric OHCA has been reported as 2.0–80.0 patients per 100,000 person-years according to age group. In general, the incidence is much higher among infants (≈70/100,000) compared with children or adolescents (≈5/100,000). Recent studies of pediatric OHCA in a population-based study in a relatively large area showed survival rates ranging from 4.7% to 7.7% (Table).

Recently, Akahane et al conducted a nationwide, population-based, observational study of the outcomes of pediatric OHCA.

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The table summarizes recent data on the characteristics of pediatric OHCA from different studies in the world. Survival rates are similar among the reports from abroad (Herlitz, Atkins, Park, Deasy, Bardai). Survival rates of school-aged children are higher than those of other age groups (Akahane, Mitani, Mitani). Key clinical predictive factors in association with survival after OHCA are discussed in the text.

CPR, cardiopulmonary resuscitation; EMS, emergency medical service; VF, ventricular fibrillation; VT, ventricular tachycardia.

Data are n (%) unless otherwise stated.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Location</th>
<th>Data collection</th>
<th>n</th>
<th>Ages included (years)</th>
<th>Males</th>
<th>Cardiac cause</th>
<th>Bystander witness</th>
<th>VF/VT</th>
<th>Bystander CPR</th>
<th>Survival</th>
<th>Favorable outcome</th>
<th>EMS response time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herlitz et al</td>
<td>Sweden</td>
<td>1990–2005</td>
<td>702</td>
<td>&lt;18</td>
<td>547 (78%)</td>
<td>58 (30%)</td>
<td>–</td>
<td>136 (19%)</td>
<td>45 (6.4%)</td>
<td>39 (5.6%)</td>
<td>–</td>
<td>7</td>
</tr>
<tr>
<td>Atkins et al</td>
<td>USA/Canada</td>
<td>2005–2007</td>
<td>624</td>
<td>&lt;20</td>
<td>386 (62%)</td>
<td>299 (31%)</td>
<td>121 (19%)</td>
<td>35 (7%)</td>
<td>9 (3%)</td>
<td>20.1</td>
<td>–</td>
<td>20.1</td>
</tr>
<tr>
<td>Park et al</td>
<td>Korea</td>
<td>2006–2007</td>
<td>971</td>
<td>&lt;20</td>
<td>613 (63%)</td>
<td>114 (59%)</td>
<td>327 (34%)</td>
<td>19 (2%)</td>
<td>9 (3%)</td>
<td>7.7</td>
<td>–</td>
<td>7.7</td>
</tr>
<tr>
<td>Deasy et al</td>
<td>Melbourne</td>
<td>1999–2007</td>
<td>193</td>
<td>&lt;16</td>
<td>114 (59%)</td>
<td>58 (30%)</td>
<td>70 (33%)</td>
<td>14 (7.2%)</td>
<td>96 (49%)</td>
<td>8.8</td>
<td>–</td>
<td>8.8</td>
</tr>
<tr>
<td>Bardai et al</td>
<td>North Holland</td>
<td>2005–2010</td>
<td>233</td>
<td>&lt;20</td>
<td>162 (70%)</td>
<td>90 (39%)</td>
<td>41 (18%)</td>
<td>17 (2%)</td>
<td>52 (22%)</td>
<td>12.1</td>
<td>–</td>
<td>12.1</td>
</tr>
<tr>
<td>Akahane et al</td>
<td>Japan</td>
<td>2005–2008</td>
<td>1,630</td>
<td>6–15</td>
<td>1,051 (64%)</td>
<td>428 (26%)</td>
<td>605 (37%)</td>
<td>152 (9.3%)</td>
<td>841 (52%)</td>
<td>7.4</td>
<td>–</td>
<td>7.4</td>
</tr>
<tr>
<td>Mitani et al</td>
<td>Japan</td>
<td>2005–2009</td>
<td>2,072</td>
<td>6–15</td>
<td>–</td>
<td>428 (26%)</td>
<td>230 (52%)</td>
<td>128 (56%)</td>
<td>161 (70%)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Mitani et al</td>
<td>Japan</td>
<td>2005–2009</td>
<td>2,072</td>
<td>6–15</td>
<td>–</td>
<td>52 (90%)</td>
<td>52 (90%)</td>
<td>48 (86%)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Table. Characteristics and Outcomes of Recent Pediatric Out-of-Hospital Cardiac Arrests (OHCA)

Data are n (%) unless otherwise stated. The table summarizes recent data on the characteristics of pediatric OHCA from different studies in the world. Survival rates are similar among the reports from abroad (Herlitz, Atkins, Park, Deasy, Bardai). Survival rates of school-aged children are higher than those of other age groups (Akahane, Mitani, Mitani). Key clinical predictive factors in association with survival after OHCA are discussed in the text.

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All rights are reserved to the Japanese Circulation Society. For permissions, please e-mail: cj@j-circ.or.jp
in Japan.\textsuperscript{8} They stratified the cases by scholastic age category and demonstrated that bystander CPR and use of PAD had a significant effect on the outcomes of pediatric OHCA. In their study, the overall survival rate at 1 month was 11% and the survival rate of OHCA in elementary school and junior high school groups was 16%, which is higher than previously reported. Moreover, OHCA patients with cardiac etiology in the junior high school group showed the highest rate of 1-month survival (30.1%) and most favorable neurological outcome (21.5%) of all groups. These findings were consistent with another population-based report that analyzed bystander-witnessed pediatric OHCA (6–15 years old) of presumed cardiac origin in Japan, showing a high survival rate (37%) and favorable neurological outcome (27%).\textsuperscript{9} Mitani et al demonstrated a further high survival rate (72%) and favorable neurological outcome (53%),\textsuperscript{2} which might be related to the hospital-based survey in which the authors selected teaching hospitals registered by the Japanese Society for Pediatric Cardiology and Pediatric Surgery. The medical staff in children’s hospitals or certain emergency centers with tertiary care might have greater experience of pediatric OHCA compared with the staff in other general hospitals. Okamoto et al found significant regional variations in the outcome of pediatric OHCA according to Japanese nationwide OHCA registry data.\textsuperscript{10} The present study also points out the important factors that might affect the characteristics and outcomes of pediatric OHCA. The OHCA children were more likely to be resuscitated and defibrillated by bystanders in the schools, under exercised-related situations, and with a pre-event follow-up, which means the site of the OHCA events, the situation of the events and the individual’s healthcare status might be important.

To improve the survival rate with favorable neurological status after a pediatric OHCA event, further effort is necessary. First, cardiologists should be involved in public education programs, with basic life support (BLS) training provided in schools to children. Second, wide dissemination of PAD devices to schools would be an effective policy for better outcomes, together with BLS training for all possible bystanders (teachers as well as students) that includes instruction on the chain of survival and usage of PAD. In addition, it might be necessary to evaluate a new CPR strategy, such as appropriate epinephrine administration for targeted pediatric OHCA cases and extracorporeal CPR. Hayashi et al investigated the outcomes among adult non-traumatic bystander-witnessed OHCA patients and demonstrated that patients who received epinephrine administration within 10 min had a significantly higher rate of neurologically intact 1-month survival compared with the non-epinephrine group (66.7\% vs. 24.9\%).\textsuperscript{11}

For the next 10 years, cardiologists should promote a combination of public education and medical innovation to improve the survival rate with favorable neurological status after a pediatric OHCA event.

\textbf{References}