Original Article

First report based on the online registry of a Japanese multicenter rapid response system: a descriptive study of 35 institutions in Japan

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Aim: Although the concept of a rapid response system (RRS) has been gradually accepted in Japan, detailed information on the Japanese RRS is not well known. We provide the first report of the RRS epidemiological situation based on 4 years of RRS online registry data.

Methods: This is a prospective observational study. All patients registered between January 2014 and March 2018 were eligible for this study. Data related to RRS including physiological measurements were recorded. The mortality rates after rapid response team/medical emergency team (RRT/MET) intervention and after 30 days were recorded as outcomes.

Results: In total, 6,784 cases were registered at 35 facilities. Cancer (23.1%) was the most common existing comorbidity. Limitation of medical treatment was identified in 12.7% of the cases. The respiratory category was most frequently activated in 41.3% of the cases. Only two institutions had received more than 15 calls per 1,000 admissions. During RRT/MET intervention, death occurred in 3.6% and transfers to intensive care units occurred in 28.2% of the cases. After 30 days, the mortality rate was significantly higher in the night than in the day shift (30.7% versus 20.4%, respectively, $P < 0.01$).

Conclusions: We report the first epidemiological study of RRS in Japan. Japanese facilities had a very low rate of RRT/MET calls and a higher mortality rate in the night than in the day shift. Further promotion to increase the number of calls and implementation of a 24-h RRT/MET is required.

Key words: in-hospital cardiac arrest, medical emergency team, rapid response system, rapid response team, unplanned ICU admission

BACKGROUND

THE RAPID RESPONSE system (RRS) has decreased the incidence of unpredicted cardiac arrest and mortality in inpatient wards worldwide.[1–5] It has become an international standard system for the timely identification of and intervention for clinically deteriorating inpatients.

This manuscript was presented at the 17th Joint Scientific Congress of the KSCCM and Japanese Society of Intensive Care Medicine, 2017, Korea.

[a]See Appendix I for In-Hospital Emergency Study Group collaborators.

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Received 9 May, 2019; accepted 7 Aug, 2019; online publication 8 Sep, 2019

Funding information

This work was supported by the Japan Society for the Promotion of Science KAKENHI (Grant Nos. JP24592755 and JP18K16548), the Japanese Society of Intensive Care Medicine, and the Japanese Society of Emergency Medicine.

Since its introduction in Japan by the Japanese Coalition for Patient Safety in 2008,[6] the concept of RRS has been gradually accepted. In 2018, it became incorporated as part of the requirement for the accreditation of the highest care level of tertiary emergency medical centers.[7] Although there are many reported studies of RRS in the world, very few have been reported from Japan; of these, most were reported from a single institution.[8–12] Therefore, detailed information with regard to Japanese epidemiological data for in-hospital emergencies is not available. In February 2014, the In-Hospital Emergency Registry in Japan (IHER-J), a multicenter RRS online registry, was introduced. It was initially sponsored by the Ministry of Education, Culture, Sports, Science, and Technology followed by both the Japanese Society of Intensive Care Medicine and the Japanese Society of Emergency Medicine through a collaborative project.

Based on 4 years of registry data from Japan, we analyzed and provided the first report of the current RRS demographic details, the rapid response team/medical emergency team (RRT/MET) call rate, the RRT/MET mortality rate, the circadian rhythm of the RRT/MET, and the issues it faces.

METHODS

Study design and participants

THIS IS A prospective observational study. The online registry was launched in January 2014 and, by the closure of this database in March 2018, the number of registered institutions had increased to 41. All patients registered between January 2014 and March 2018 were eligible for inclusion into this study. Each institution voluntarily and prospectively registered data for RRT or MET calls through the IHER-J online registry form, which could be electronically accessed. The entire database was securely managed by the University Hospital Medical Information Network – Clinical Trials Registry (UMIN-CTR) of Tokyo University (Tokyo, Japan). This multicenter RRS epidemiological study using this online registry was registered on 16 October, 2013, in the UMIN-CTR (UMIN000012045) and approved by the institutional research board committee of St. Marianna University Hospital (#2498) (Kawasaki, Japan). In order to focus on acute care hospitals, we excluded one institution from analysis, as over half of the beds in that institution were allocated for long-term care.

Variables collected

At the time of registration, each institution reported the number of beds, RRT/MET members, and the method used to activate the teams. Registered data comprised age, sex, physiological measurements including respiratory rate, body temperature, blood pressure, heart rate, oxygen saturations, and level of consciousness graded on the AVPU scale (alert, voice response present, pain response present, and unresponsive), activation trigger, code status at the time of RRT/MET calls, and comorbidities. The following data related to RRS were also recorded: occupation of caller, time and place of activation, and the kind of team that handled the case. Interventions by the team, such as intubation and fluid bolus administration, were recorded.

Outcome measures

The outcome measures of interest were the number of RRT/MET calls per 1,000 admissions, rate of unplanned transfers to intensive care units and mortality rates at the time of RRT/MET intervention and after 30 days. We collected new admission numbers from each facility based on diagnosis procedure combination data, which is the Japanese version of the diagnosis-related group, and is used for health-care insurance to analyze RRS activation rates. For this analysis, we excluded facilities that had been registered for less than 6 months or had fewer than 20 cases with comprehensive data. The circadian rhythm of the RRT/MET calls and mortality were analyzed in the day shift (8.00 AM–5.00 PM) and the night shift (5.00 PM–8 AM). In this analysis, we excluded incomplete data for outcome and activation time.

Statistical methods

All data manipulation was carried out using IBM SPSS Statistics (Statistics for Windows, version 25.0; IBM, Armonk, NY, USA). Statistical significance was defined as a *P*-value <0.05 using the χ^2-test.

RESULTS

Demographic details

A TOTAL OF 6,784 cases were registered at 35 facilities during the study period from January 2014 to March 2018. We excluded 900 cases from one long-term care facility from the analysis. We also excluded 259 cases from the analysis of call rate and 1,219 cases from the analysis of the circadian rhythm of the RRT/MET calls (Fig. 1).

Patient characteristics are shown in Table 1. Their mean age was 66.0 ± 19.7 years, and 59.8% of patients (3,517/5,884) were male. The most common existing comorbidity was cancer (23.1%; 1,362/5,884), followed by postoperative patients (12.5%; 738/5,884) and sepsis (9.1%; 537/5,884). Limitation of medical treatment (LOMT) was identified in

12.7% (627/4,951) of cases. Almost half of all patients were admitted to medical departments (49.8%; 2,921/5,863), and 32.4% (1,901/5,863) were admitted to surgical departments. Only 1.1% (65/5,863) of the patients were admitted to pediatric departments.

Reasons for RRT/MET activation

The most frequent category of activation criteria was the respiratory category, which accounted for 41.4% (2,434/5,884) of the cases. The most activated reason was desaturation (33.6%; 1,978/5,884), followed by registered nurse's concerns (28.3%; 1,667/5,884), altered mental status (28.1%; 1,654/5,884), hypotension (22.2%; 1,306/5,884), and tachypnea (15.9%; 937/5,884). In total, 16.3% (960/5,884) and 5.2% (306/5,884) of the cases met two and three categories of activation criteria, respectively (Table 2).

Interventions

Regarding interventions during RRT/MET calls, cardiopulmonary resuscitation, intubation, and bag valve mask ventilation had to be carried out on 7.4% (438/5,884), 14.9% (874/5,884), and 15.9% (933/5,884) of the cases, respectively (Table 3). Bag valve mask ventilation or intubations were needed in 21.5% of the cases.

Call outcomes

During RRT/MET calls (Table 4), cardiopulmonary arrest and death occurred in 6.9% (407/5,884) and 3.6% (208/5,773) of the cases, respectively. Intensive care unit transfers after RRT/MET calls occurred in 28.2% (1,626/5,773) of the cases, and the mortality rate after 30 days was 24.9% (1,195/4,799).

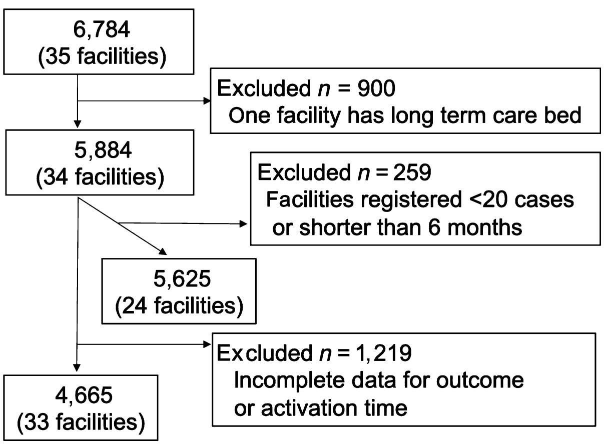

Fig. 1. Flowchart of this multicenter study of the rapid response system in Japanese health-care facilities (January 2014–March 2018).

Call rate of RRT/MET

The rate of RRT/MET calls and the total registered number of RRT/MET cases in each institution are shown in Figure 2. Most institutions had a very low rate of activation per 1,000 admissions. Only two institutions (8.3%, 2/24) had more than 15 RRT/MET calls per 1,000 admissions.

Circadian rhythm of RRT/MET calls

The circadian rhythm of the RRT/MET calls is shown in Figure 3. The average number of RRT/MET calls per hour in the day shift and night shift was 285.6 and 139.7, respectively. The mortality rate in these shifts was 20.4% (524/2,570) and 30.7% (644/2,095), respectively ($P < 0.01$).

DISCUSSION

THIS IS THE first report on the epidemiology of RRS in Japan using data from the multicenter online registry.

Table 1. Characteristics of Japanese patients for whom a rapid response system was activated, January 2014–March 2018 (n = 5,884)

Variables	Number	%
Age, mean ± SD	66.0 ± 19.7	
Sex: male	3,517	59.8
Existing comorbidity		
Cancer	1,362	23.1
Postoperative patients	738	12.5
Congenital heart disease	38	0.6
Sepsis	537	9.1
LOMT[†]	627	12.7
Admitted department[‡]		
Medical	2,921	49.8
Surgical	1,901	32.4
Minor[§]	446	7.6
Ob/gyn	159	2.7
Pediatric	65	1.1
Psychiatric	54	0.9
Other	382	6.5

[†]Data from 4,951 cases.
[‡]Data from of 5,863 cases.
[§]Urology, otolaryngology, dermatology, ophthalmology.
LOTM, limitation of medical treatment; Ob/gyn, obstetrics/gynecology; SD, standard deviation.

Table 2. Reason for rapid response team/medical emergency team calls (n = 5,884)

Call criteria	Number†	%
Respiratory‡	2,434	41.4
Desaturation	1,978	33.6
Tachypnea	937	15.9
Shortness of breath	756	12.8
Suffocation	263	4.5
Bradypnea	366	6.2
Cyanosis	210	3.6
Circulatory‡	1,565	26.6
Hypotension	1,306	22.2
Tachycardia	565	9.6
Bradycardia	408	6.9
Neurology‡	1,532	26.0
Altered mental status	1,654	28.1
Seizure	200	3.4
Agitation	48	0.8
Other‡	1,964	33.4
RN concern	1,667	28.3
Delayed reaction	145	2.5
Decreased urine output	113	1.9
Anaphylaxis	109	1.9
Uncontrollable pain	69	1.2
Trauma	42	0.7
Other than the above	981	16.7
Met two categories§	960	16.3
Respiratory and cardiology	363	6.1
Respiratory and neurology	319	5.4
Cardiology and neurology	278	4.7
Met all three categories§	306	5.2

†Multiple answers were allowed.
‡Cases that met one of the criteria in the category.
§Categories including respiratory, cardiology, and neurology.
RN, registered nurse.

Table 3. Interventions during rapid response team/medical emergency team calls (n = 5,884)

Variable	Number†	%
Test order	2,009	34.1
Oxygen supplement	1,828	31.1
Fluid bolus	1,589	27.0
Medication	1,541	26.2
Suction	992	16.9
BVM	933	15.9
Intubation	874	14.9
CPR	438	7.4
Transfusion	151	2.6
Airway insertion	115	1.9
Nebulizer	69	1.2
None	626	10.6

†Multiple answers were allowed.
BVM, bag valve mask ventilation; CPR, cardiopulmonary resuscitation.

Table 4. Outcome of rapid response team/medical emergency team calls (n = 5,884)

Variable	Number	%
CPA on arrival of RRS	354	6.0
CPA during RRS	53	0.9
Disposition after RRS activation†		
Death	208	3.6
ICU transfer	1,626	28.2
Stay in ward	2,842	49.2
Discharge (outpatient)	402	7.0
Other	695	12.1
New DNAR order after RRS‡	252	5.3
Outcome after 30 days§		
Death	1,195	24.9
Discharge	1,624	33.8
Hospitalized	1,542	32.1
Transfer to other hospital	438	9.1

†Data from 5,773 cases.
‡Data from 4,743 cases.
§Data from 4,799 cases.
CPA, cardiopulmonary arrest; DNAR, do not attempt resuscitation; ICU, intensive care unit; RRS, rapid response system.

First, unfortunately, the most notable characteristic of the Japanese RRS registry is the very low rate of RRT/MET calls. In more established hospitals that implement RRS, the RRT/MET is activated for 25–70 cases per 1,000 admissions.[13–16] In the MERIT study, a cluster-randomized controlled trial in Australia, a low number of RRT/MET calls was considered one of the most important limitations for favorable outcomes after RRS implementation.[17,18] In the MERIT study, RRT/MET calls numbered 8.7 cases per 1,000 admissions, which amounted to only 30% of the cases that were expected to be called in.[18] In our study, only 16.7% (4/24) of the facilities had a better RRS activation call rate than that in the MERIT study (Fig. 2). It was reported that increasing RRT/MET calls improves patient outcomes.[14] Thus, it is obvious that the Japanese RRS does not work optimally. A questionnaire survey of 1,242 medical staff also reports that the main obstacles for RRS implementation in Japan are: (i) shortage of educated physicians and/or nurses for RRT/MET, (ii) lack of leadership or facility support for installation, (iii) insufficient training programs, (iv) non-cooperative primary team physicians.[19] Promotion

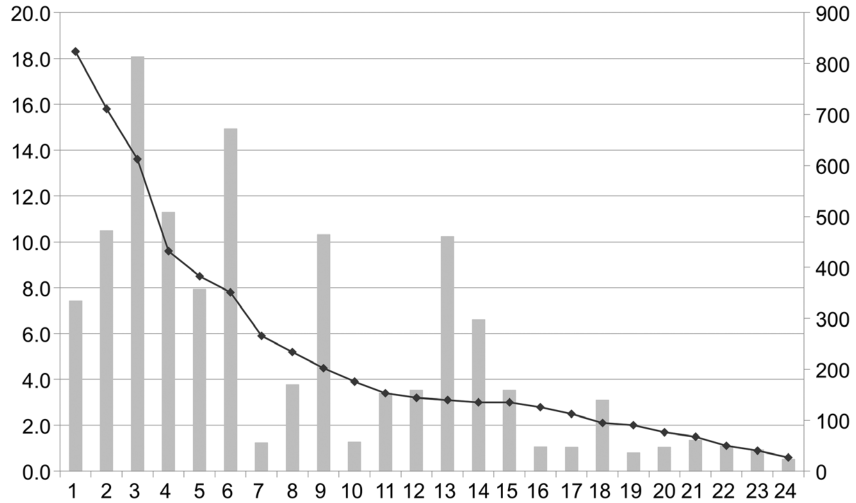

Fig. 2. Registered number and activation rate of rapid response team/medical emergency team (RRT/MET) calls in Japanese health-care facilities (January 2014–March 2018). Black line indicates RRT/MET calls per 1,000 admissions; columns show the number of registered cases. *x*-axis, hospitals; *y*-axis (left), number of RRT/MET calls per 1,000 admissions; *y*-axis (right), number of registered cases.

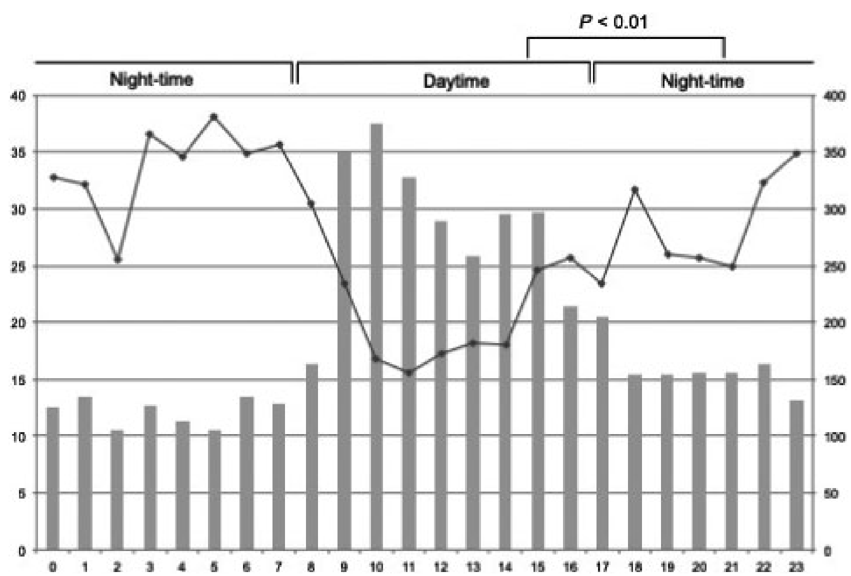

Fig. 3. Circadian rhythm of rapid response team/medical emergency team (RRT/MET) calls in Japanese health-care facilities (January 2014–March 2018) and mortality rate of patients. The rate of RRT/MET calls and mortality are shown for every hour (0–23). Black line indicates 30-day mortality; columns indicates number of registered cases. *x*-axis, time (h); *y*-axis (left), 30-day mortality (%); *y*-axis (right), number of registered cases.

as a national policy, such as in the Netherlands,[4] is required in order to have, for example, privileged remuneration for medical fees. Although The Joint Commission sets RRS as a requirement for all hospitals, the Japan Council for Quality Health Care does not. Our study and the following analyses of the registry will lead the way for constructing RRS infrastructure.

Second, Japanese RRS calls were delayed for activation and intervention, and 6.9% of RRT/MET calls resulted in a cardiac arrest during RRT/MET intervention. Resuscitative procedures, such as bag valve mask ventilation or intubation, were needed in 21.5% of the cases. Mortality at the time of the RRT/MET intervention was 3.6% in our study, whereas it was previously reported as 1%.[4] This implies that RRT/MET calls in Japan are delayed and callers have to wait for their cases to be activated until patients meet the "severe enough" criterion. Indeed, 22.0% of participating hospitals had a single RRT/MET team and code blue team. This tends to identify the RRS as a system similar to code blue, or as "expanded code blue." Thus, we need to re-emphasize the difference between RRS and code blue to make the former work effectively.

To solve these problems, we need to build a system that overcomes such barriers. Early warning score is expected to be the solution. It is used as an automated track-and-trigger system and could be added to the existing RRS system as one of the main wheels of patient safety. Further studies are required to validate the early warning score in Japan. Moreover, machine learning and artificial intelligence are promising tools of advancement in this field.

Third, our data revealed that the circadian rhythm of RRT/MET calls was associated with the variation in mortality rate. Mortality was significantly higher during the night shift than during the day shift. Taking the high mortality rate in the night shift, which has been previously reported,[11] into consideration, different approaches to increase RRT/MET calls during the night shift are needed.

Furthermore, lower call rates during the night shift were observed. One reason is that 46.3% (19/41) of the participating hospitals had 24-h RRT/MET services as of July 2018. A previous study from Australia revealed that RRT/MET calls had three peaks at 8.00 AM, 2.00 PM, and 7.00 PM. The highest peak was seen at 7.00 PM. Our data did not show a peak in the night shift, and the highest peak was seen in the morning at 10.00 AM. This might be a consequence of overlooking deteriorating patients during the night shift until the handover in the morning. As deterioration happened during the night shift, a 24-h RRT/MET service is needed. As mentioned above, the shortage of physicians in emergency and critical care fields is a barrier to establishing 24-h RRT/MET services. Although increasing the number of these physicians—which is not easy—should be prioritized, it would be easier and more effective to educate advanced registered nurses and nurse practitioners in the critical care field.

Finally, only 12.7% of those who underwent RRT/MET review had pre-existing LOMT in our study. However, another study reported that 25% of RRT/MET cases had pre-existing LOMT.[20] Advanced care planning has not been commonly used, and warnings have been issued about misunderstanding the Do Not Attempt Resuscitation (DNAR) order in Japan.[21] Because Japan is the world's most rapidly aging society,[22] we are under pressure to overcome these serious issues. In a previous study, 10% of RRT/MET calls resulted in new implementation of LOMT.[20] Thus, RRT/MET calls provide a chance to set an appropriate code status before patients undergo undesired advanced treatment. The RRS also has the potential to improve end-of-life quality. A Japanese long-term care facility reported that RRS implementation allowed families more time to prepare for the impending death of DNAR patients.[23]

Study strengths and limitations

The main strength of this study is that it is the first epidemiological study from a multicenter registry in japan. Despite all the potential implications of its findings, this study has several limitations. First, all the cases that met the activation criteria for RRT/MET did not seem to be covered; in other words, very few such cases were called in. An increased number of calls might have provided different information. Furthermore, there were several excluded cases from a long-time care facility or that had incomplete data, and not all facilities that had RRS participated in the online registry. However, to counter this point, it cannot be denied that this registry does not represent the current state of in-hospital emergencies. Second, we did not consider the RRS variety in each facility. Finally, there are some facilities that did not have a 24-h RRT/MET service, which could have a significant impact on daily fluctuations.

Implications for clinicians and policy makers

This study could be a benchmark for Japanese hospitals to assess their standings. Additionally, these results re-emphasize for policy makers the necessity of facilitating RRS implementation across the country.

Future research

There is still room for research on the differences in the characteristics of patients who need RRT/MET intervention in terms of day and night shifts and barriers for RRT/MET calls. Furthermore, the development of validated prediction models for in-hospital adverse events is strongly needed. New innovations, such as wearable devices for patient monitoring, and machine learning and artificial intelligence for real-time analysis should progress in this area.

CONCLUSION

THE EPIDEMIOLOGY OF RRT/MET patients in Japan is similar to that reported elsewhere, except in places with severe conditions, a low rate of RRT/MET calls, and a low rate of LOMT. Our data revealed the possibility of overlooking deteriorating patients and the higher mortality of RRT/MET cases during the night shift. Our study and the following analyses of the registry will lead the way for constructing better RRS infrastructure.

ACKNOWLEDGEMENTS

WE THANK THE In-Hospital Emergency Committee in Japan, organized by the patient safety promotion committee in the Japanese Society of Emergency Medicine, the rapid response system committee in the Japanese Society of Intensive Care Medicine, Japan Resuscitation Council, Japanese Society of Emergency Pediatrics, Japanese Circulation Society, Japanese Society for Quality and Safety in Healthcare, and the Japanese Coalition for Patient Safety for contributions to this study. We thank the In-Hospital Emergency Study Group for helping with data collection. We also thank Hsiang-Chin Hsu for advice on data analysis.

DISCLOSURE

Approval of the research protocol: The study protocol was reviewed and approved by the ethics committee of all 35 participating institutes in Japan (IRB No. 2498, St. Marianna University School of Medicine, Japan, the representative for IHER-J).

Informed consent: The need for written informed consent was waived because this study used anonymous case registry data and was undertaken by the patient safety committee.

Registry and the registration no. of the study/trial: This study was registered 16 October 2013 with UMIN-CTR (UMIN000012045), https://www.umin.ac.jp/ctr/index-j.htm.

Animal studies: N/A.

Conflict of interest: None declared.

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APPENDIX I

COLLABORATORS OF THE IN-HOSPITAL EMERGENCY STUDY GROUP

ST. MARIANNA UNIVERSITY Hospital (Shigeki Fujitani); NHO Ureshino Medical Center (Shinsuke Fujiwara); Kitazato University Hospital (Masayasu Arai); Osaka City General Hospital (Hideki Arimoto); Mie University Hospital (Eiji Kawamoto); Chibune General Hospital (Toshimasa Hayashi); Nagoya City University Graduate School of Medical Sciences (Yoshiki Sento); Hiroshima Prefectural Hospital (Takao Yamanoue); JA Hiroshima General Hospital (Natsuo Kawamura); Kyoritsu General Hospital (Yuta Kawase); Kobe City Medical Center General Hospital (Kazuma Nagata); Fukushima Medical University Aizu Medical Center (Takuro Saito); Tomishiro Central Hospital (Masahiro Tamashiro); St. Luke's International Hospital (Kazuhiro Aoki); Hyogo College Of Medicine College Hospital (Atsushi Miyawaki); Wakayama Medical University (Naoaki Shibata); Jichi Medical University Saitama Medical Center (Tomoyuki Masuyama); Shizuoka Children's Hospital (Tatsuya Kawasaki); Japanese Red Cross Musashino Hospital (Shinichiro Suzaki); Seirei Hamamatsu General Hospital (Toshiaki Oka); Hikone Municipal Hospital (Tomoyuki Ikeda); Fukushima Medical University Hospital (Kazuo Ouchi); Shimane Prefectural Central Hospital (Yuji Yamamori); Kameda Medical Center (Yoshiro Hayashi); Kurashiki Central Hospital (Takanao Otake); Miyazaki Prefectural Miyazaki Hospital (Takeshi Aoyama); Gunma University Hospital (Masaru Tobe); Okayama Saiseikai General Hospital (Toshifumi Fujiwara); Ibaraki Prefectural Central Hospital (Ryosuke Sekine); Chiba University Graduate School of Medicine (Taka-aki Nakada).