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Clinical paper

Rapid response system in Japanese outpatient departments based on online registry: Multicentre observational study



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Abstract

Aim: The rapid response system (RRS) has become well known as a patient safety system to reduce adverse in-patient events, and it is also required to respond to patients in the outpatient department. However, only few studies have reported on the RRS in the outpatient department. We analysed the current status of the RRS in the outpatient department based on a multicentre online registry in Japan.

Methods: This is a prospective multicentre observational study. Among the cases registered in the RRS online registry from January 2014 to March 2018, cases from the outpatient department, consisting of the general outpatient department, radiation department, dialysis department, endoscope department, rehabilitation department, and the surrounding areas were eligible for this study.

Results: A total of 6784 cases were registered, and 1022 cases were included. The main reason for activation was altered mental status (39.1%). Incomplete vital sign recording at activation was 67.0%, whereas body temperature (57.0%) and respiratory rate (36.4%) deficits were frequent. The most common intervention during RRS activation was fluid bolus (38.2%) and oxygen supplementation (30.9%). The general outpatient department accounted for nearly half of the activation locations. The 30-day mortality rate for the location was significantly higher in the dialysis department ($P < 0.001$).

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Conclusions: We have reported the first study of RRSs in outpatient departments at multicentre facilities in Japan. The difference in the mortality rate for the location was clarified. Future tasks will involve clarifying the RRS outcome indicators in the outpatient department and examining the effectiveness thereof.

Keywords: Rapid response system, Outpatient department, Patient safety system, Vital sign, 30-day mortality

Introduction

The rapid response system (RRS) is recognised as a patient safety system that reduces adverse events in hospitalised patients through early detection and intervention in deterioration. Since the concept of the RRS was reported in 1995,¹ its effectiveness has been demonstrated worldwide.^{2–4} In Japan, the introduction of the RRS was promoted by the Japanese Coalition for Patient Safety in 2008, and it has gradually been expanded thereafter. In 2014, the unique RRS online registry for Japan, the In-Hospital Emergency Registry in Japan (IHER-J), was introduced, and many cases have been registered. In 2019, the first epidemiological study of the RRS in Japan based on the registry was reported.⁵

Individuals other than inpatients are present in hospitals. Several locations are shared by inpatients, outpatients, family members, staff, and visitors. Patient deterioration may suddenly occur at any location, and not only in the hospital wards. The RRS is required to be dispatched and respond to all locations on the hospital premises, including the outpatient department. The RRS is becoming an integral part of the patient safety system of a hospital, wherever it may be located. Although numerous reports on RRSs are available globally, most of these are related to hospitalised patients.^{2–4} Several studies on RRSs in non-hospitalised patients have been conducted, but only at a single centre, and their findings have been inconsistent.^{6–10} Therefore, in this study, we used RRS online registry data to analyse the current status of RRS cases in the outpatient departments of multicentre facilities in Japan.

Methods

This is a prospective multicentre observational study. The RRS online registry (IHER-J) was launched in January 2014, and all patients enrolled by March 2018 were included in the study. As on March 2018, the number of registered institutions was 41. Each institution accessed the IHER-J online registry form and registered its own RRS case. This online registry was registered in the University Hospital Medical Information Network Clinical Trial Registry (UMIN000012045) of the University of Tokyo, and the entire database was securely managed. The multicentre RRS epidemiological study using this online registry was approved by the Institutional Research Committee of St. Marianna University School of Medicine Hospital (#2498).

During registration, each institution had reported the number of beds, RRS team members, and activation criteria. The registered data included the age, sex, clinical department, reason for activation, vital signs at activation (respiratory rate, temperature, blood pressure, heart rate, and Glasgow coma scale (GCS)), RRS intervention content, activation location, and outcome. Furthermore, the code status at the time of the RRS activation, comorbidity, caller information, activation time, and team type were recorded. The outcome indicators of interest were the disposition after RRS

activation (death, ICU admission, transferred to ward, discharge), and 30-day mortality in the outpatient department. With reference to previous studies,^{6–9} the outpatient department included the general outpatient department (examination room, waiting room, treatment room, chemotherapy room, reception/accounting, and entrance), radiation department (X-ray room, CT room, MRI room, angiography room, and fluoroscopy room), dialysis department, diagnostic department (physiological laboratory and specimen laboratory), endoscope department, rehabilitation department, and the surrounding areas (restrooms, stairs, shops, restaurants, escalators, elevators, and outdoors). In the outpatient department analysis, cases in which the RRS was activated from the emergency room, operating room, hospital ward area, and indistinguishable areas were excluded.

IBM SPSS Statistics (Statistics for Windows, version 26.0; IBM, Armonk, NY, USA) was used for the statistical analyses. In the obtained data, the continuous variables were expressed as the mean and standard deviation, whereas the nominal variables were expressed as percentages. We examined the outpatient discharge rate and the 30-day mortality rate for the location of RRS activation. Logistic regression analysis was used to calculate the odd ratios and 95% confidence intervals after simultaneous control for potential confounders.

Results

A total of 6784 registered cases were recorded in the RRS online registry, with 1022 included cases (Fig. 1). Table 1 presents the characteristics of the RRS cases in the outpatient department. The patient backgrounds included a mean age of 63.6 (\pm 19.4) years and 568 males (55.6%). The main reasons for RRS activation were altered mental status: 400 cases (39.1%), hypotension: 255 cases (25.0%), and staff concern: 239 cases (23.4%) (Table 2). Moreover, there were

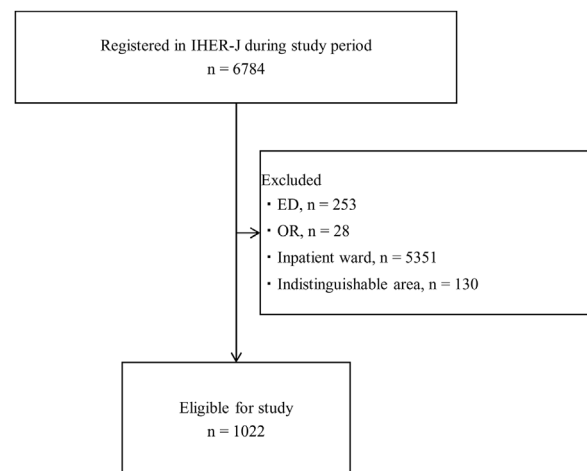


Fig. 1 – Enrolment diagram.
IHER-J: In-Hospital Emergency Registry in Japan; ED: emergency department; OR: operating room.

Table 1 – Baseline characteristics of patients (n = 1022).

Characteristics	
Age, mean \pm SD	63.6 \pm 19.4
Sex: male, n (%)	568 (55.6)
Existing comorbidity, n (%)	
Cancer	226 (22.1)
Postoperative patients	34 (3.3)
Congenital heart disease	5 (0.5)
Sepsis/suspected sepsis	34 (3.3)
Clinical department, n (%)	
Internal medicine	561 (54.9)
Surgical	221 (21.6)
Minor ^a	77 (7.5)
Ob/gyn	41 (4.0)
Psychiatric	16 (1.6)
Paediatric	11 (1.1)
Others	95 (9.3)

SD: standard deviation; Ob/gyn: obstetrics/gynaecology.
^a Urology, otolaryngology, dermatology, ophthalmology.

Table 2 – Reasons for RRS activation (n = 1022).

Call criteria	Number ^a (%)
Respiratory ^b	
Desaturation	229 (22.4)
Shortness of breath	93 (9.1)
Tachypnoea	89 (8.7)
Bradypnea	61 (6.0)
Cyanosis	47 (4.6)
Suffocation	39 (3.8)
Cardiology ^b	
Hypotension	255 (25.0)
Bradycardia	82 (8.0)
Tachycardia	58 (5.7)
Neurology ^b	
Altered mental status	400 (39.1)
Seizure	39 (3.8)
Others ^b	
Staff concern	239 (23.4)
Anaphylaxis	76 (7.4)
Uncontrollable pain	28 (2.7)
Trauma	27 (2.6)
Others	193 (18.9)

RRT/MET: rapid response system/medical emergency team.
^a Multiple answers were allowed.
^b Cases that met one of the criteria in the category.

685 cases (67.0%) with incomplete vital sign recording at activation, body temperature: 583 cases (57.0%), respiratory rate: 372 cases (36.4%), blood pressure: 225 cases (22.0%), GCS: 192 cases (18.8%), and heart rate: 147 cases (14.4%). Intervention during RRS activation was performed in 89.8% of cases, intravenous fluid bolus in 390 cases (38.2%), oxygen supplementation in 316 cases (30.9%), medication in 273 cases (26.7%), bag valve mask ventilation in 128 cases (12.5%), intubation in 105 cases (10.3%), suction in 94 cases (9.2%), and cardiopulmonary resuscitation in 73 cases (7.1%). The RRS activation locations were as follows: general outpatient department: 488 cases (47.7%), radiation department: 273 cases (26.7%), dialysis department: 59 cases (5.8%), diagnostic

Table 3 – Outcomes for RRS activation (n = 1022).

Variables	Number (%)
CPA on arrival of RRS	64 (6.3)
CPA during RRS	6 (0.6)
Disposition after RRS activation ^a	
Death	16 (1.6)
ICU admission	190 (18.9)
HCU admission	51 (5.1)
Transferred to ward	328 (32.6)
Discharge (outpatient)	317 (31.5)
Others	105 (10.4)
30-day outcomes ^b	
Death	76 (8.2)
Discharge	651 (70.3)
Hospitalised	138 (14.9)
Transferred to another hospital	51 (5.5)
Others	10 (1.1)

RRT/MET: rapid response system/medical emergency team; CPA: cardiopulmonary arrest; ICU: intensive care unit; HCU: high care unit.
^a Data from 1007 cases.
^b Data from 926 cases.

department: 55 cases (5.4%), endoscope department: 41 cases (4.0%), rehabilitation department: 31 cases (3.0%), and others: 75 cases (7.3%) (Fig. 2). The outcomes for RRS activation included transferred to ward: 328 cases (32.6%), discharge from the outpatient department: 317 cases (31.5%), ICU admissions: 190 cases (18.6%), death at RRS intervention: 16 (1.6%), and death within 30 days: 76 cases (7.4%) (Table 3). The logistic regression analysis demonstrated that the discharge rate from the outpatient department after RRS activation was significantly higher in the laboratory department at 64.7% (adjusted odds ratio, 8.30; 95% confidence interval, 4.24–16.26; $P < 0.001$). The 30-day mortality for the activation location was significantly higher in the dialysis department at 26.0% ($P < 0.001$) (Table 4). The existing comorbidities of patients in the dialysis department were more likely to have a higher rate of sepsis/suspected sepsis compared to other activation locations (10.2% vs 2.9%; $X^2 = 9.12$, $df = 1$, $P = 0.003$).

Discussion

This study is the first to analyse and report the current status of the RRS in outpatient departments using multicentre online registry data in Japan.

Previous studies on the RRS in outpatient departments found that the mean age was 47–68 years, the percentage of male was 46–74%, and 8–13% of RRS activation cases were non-hospitalised patients, among which 26–74% were hospitalised, 1–18% were in ICU admission, and 0–2% died during RRS.^{6–10} In this study, without the excluded cases, the outpatient department cases of the RRS online registry accounted for 15.1%. The characteristics of patients and the rates of ICU admission and death at RRS intervention were similar to those of previous studies.^{6–10} These indicate that the activated cases in the outpatient department included, less frequently, severe ones. In previous studies of outpatients, interventions during RRS activation demonstrated that non-invasive interventions such as intravenous fluid bolus (10–87%) and oxygen supplementation (33

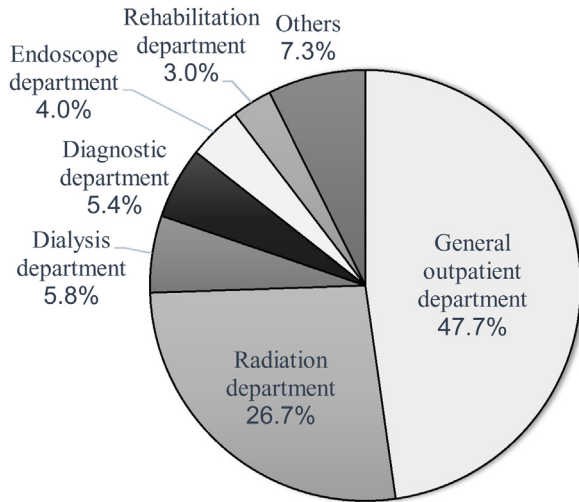


Fig. 2 – RRS activation locations (n=1022).

The activation locations were as follows: general outpatient department: 488 cases (47.7%), radiation department: 273 cases (26.7%), dialysis department: 59 cases (5.8%), diagnostic department: 55 cases (5.4%), endoscope department: 41 cases (4.0%), rehabilitation department: 31 cases (3.0%), and others: 75 cases (7.3%).

–46%) were mainly performed, and few cases required invasive interventions such as intubation (less than 3%) and cardiopulmonary resuscitation (less than 1%),^{6–8,10} with similar results in our study. Accidents will happen, and sudden deterioration can occur anywhere in the hospital. High-risk tests and procedures are performed even in outpatient departments, including sedation,^{11,12} intravascular contrast media,¹³ gastrointestinal endoscopy,¹⁴ outpatient surgery,¹⁵ outpatient chemotherapy,¹⁶ and dialysis.^{17,18} Outpatient departments have their own risks and diversity. The outpatient department is the gateway to the hospital and is connected to the outside. Outpatients who have not been diagnosed or treated need to wait, and referrals are received from other hospitals. Moreover, many people who are not registered as patients move within this region. Areas such as reception/accounting, restaurants, and shops do not have sufficient

equipment for deterioration (for example, monitoring, oxygen, suction, and lighting) or medical staff. Inpatients also visit for tests and procedures. Although RRS activation was as high as 15.1% from the outpatient department, the frequency of deterioration that required invasive intervention was low. However, there were severe cases. In the event of a life-threatening emergency, the sudden response of staff who had little experience with invasive interventions such as intubation and cardiopulmonary resuscitation created greater confusion. Therefore, the training of staff who are not accustomed to responding to deterioration is important,¹⁹ and an RRS, in which a team of experienced and trained experts respond to deterioration, is necessary in the outpatient department.

Although there are no previous studies in the outpatient department on measuring vital signs before deterioration, in a study of inpatients, 15% had no vital signs documented in the 24-h period prior to cardiac arrest.²⁰ In our study, incomplete vital sign recording at RRS activation in the outpatient department occurred in more than half the patients, and there were numerous deficits in the body temperature and respiratory rate. The reasons for the incomplete vital sign recording may be the measurement and documentation of vital signs. Documenting the vital signs of electronic health records has been mentioned in previous studies.²⁰ The fact that there was a difference in deficiency rate among vital signs, and that altered mental status and staff concern were the top reasons for activation—but that abnormalities in respiratory rate, heart rate, and temperature were not the top reasons for activation—suggested that there was scope for improvement in vital sign measurement. In previous studies as well, altered mental status was the main reason for activation, as opposed to abnormalities in respiratory rate and temperature.^{6–8,10} The national early warning score (NEWS) is an early warning score that assesses the vital signs and evaluates the risk of deterioration based on the total score. In a study that analysed the association between the NEWS and clinical outcomes among outpatients who had activated the RRS, the area under the curve for the high-risk patient group (NEWS \geq 7) at the time of deterioration for predicting hospital admission was 0.85 (95% confidence interval, 0.67–1.10).¹⁰ The measurement of vital signs without loss and NEWS may enable early recognition and improve the prognosis of critically ill patients even in the outpatient department. Several studies have demonstrated that algorithms based on deep learning can detect cardiac arrest with high accuracy and few false alarms.²¹ Nonetheless, vital sign measurement is essential. However, complete measurement of the vital signs

Table 4 – Logistic regression analysis results showing 30-day mortality rate for location of RRT/MET events (n=926).

Location	30-day mortality (%)	Crude OR (95% CI)	P value	Adjusted OR ^b (95% CI)	P value
General outpatient department	36/443 (8.1)	1.01 (0.57–1.78)	0.98	1.13 (0.63–2.01)	0.68
Radiation department	20/248 (8.1)	1 (Reference)		1 (Reference)	
Dialysis department	13/50 (26.0)	4.01 (1.84–8.73)	<0.001	3.87 (1.74–8.61)	<0.001
Endoscope department	3/39 (7.7)	0.95 (0.27–3.36)	0.94	0.80 (0.22–2.85)	0.73
Rehabilitation department	2/29 (6.9)	0.84 (0.19–3.81)	0.83	0.83 (0.18–3.81)	0.81
Others ^c	2/117 (1.7)	0.20 (0.05–0.86)	0.03	0.24 (0.04–1.04)	0.06

CI: confidence interval; OR: odds ratio.

^a Ninety-six observations with missing data on the 30-day outcome were deleted from the analysis.

^b Adjusted ORs for sex and age.

^c The diagnostic department merged with others during logistic regression analysis as there were no 30-day deaths.

of all the patients in the outpatient department with many diverse patients has limitations when conventional measurement methods are used. Vital sign measurement is a major issue for the early recognition of deteriorating patients in the outpatient department. To address these problems, it is necessary to develop monitoring technology that can rapidly measure vital signs without omission.

In a previous study that analysed RRS activation in the dialysis department, patients who activated the RRS exhibited a mortality rate that was nearly six times higher than that of the general inpatients. Moreover, critical events occur not only during dialysis but also before and after dialysis, including during transportation.¹⁷ An analysis of cardiac arrest cases during haemodialysis indicated that there was a statistically significant difference in the return of spontaneous circulation rate ($P=0.048$) only in the event of an emergency call.¹⁸ Although our study did not examine whether the patients with RRS activation in the dialysis department were more likely to be pre-, peri-, or post-dialysis, we found that the dialysis department had a significantly higher 30-day mortality rate than the other outpatient departments. It was clear that a difference in mortality existed among the outpatient departments depending on the activation location. Dialysis patients are more likely to have comorbidities such as the cardiovascular system, electrolyte and acid-based derangement, especially potassium abnormalities. Furthermore, hypotension is a commonly known acute complication during dialysis. Sepsis has been reported as a risk factor for intradialytic hypotension (odds ratio, 3.57; 95% confidence interval, 1.31–9.75; $P=0.013$).²² Our study showed that patients in the dialysis department may be more likely to have comorbidities of sepsis/suspected sepsis compared to other activation locations. We did not find that the dialysis department had more RRS activation due to hypotension than other activation locations, but the combination of comorbidities, including sepsis, may be responsible for the higher 30-day mortality rate in the dialysis department compared to other activation locations. A stratified approach to prevent intradialytic hypotension was suggested in the European Best Practices Guideline.²³ In a multicentre randomised controlled trial of haemodialysis patients who are prone to hypotension, the use of blood volume monitoring reportedly reduced hypotension during dialysis by 30% compared with conventional haemodialysis ($P=0.004$).²⁴ To prepare for patient collapse in the dialysis department, we recommend that dialysis patients should be assessed for risk of comorbidities, and hospitals should implement preventive strategies such as enhanced monitoring and adjustment of dialysis methods. It is necessary to identify patients at high risk of deterioration in the early stage and to intervene promptly.

The previous study was a report from a single institution,^{6–10} whereas this study clarified the current status of the RRS in outpatient departments using multicentre data in Japan. Furthermore, we clarified the issues of vital sign measurement and the differences in the risk of greater severity depending on the activation location.

This study had several limitations. First, there was no information regarding patient categories (for example, outpatients, inpatients, patient families, visitors, and staff). Our study did include an analysis that considered patient categories because the study population was segmented based on the activation location. Second, our study lacked information regarding the diversity of the RRS, factors affecting the medical care system such as the facilities and number of staff, and the ICU admission criteria at each facility. Moreover, not all facilities that have introduced an RRS in Japan participate in this registry; hence, the results of this study could not be generalised, and the effectiveness of the RRS in the outpatient department remains unknown.

Unexpected cardiac arrest, unexpected death, and unplanned ICU admission are common outcome indicators for assessing the effectiveness of the RRS internationally, but these are all for inpatients.^{25,26} Cardiac arrest in the outpatient department is rare, accounting for less than 1% of in-hospital cardiac arrest.²⁷ To determine the effectiveness of the RRS in the outpatient department, new RRS outcome indicators that are not limited to the reduction in cardiac arrest are required. In future, it will be necessary to consider the prospective study of all the outpatients, and not only those who had activated the RRS in the outpatient department.

Conclusions

We have reported the current status of the RRS in Japanese outpatient departments based on the RRS online registry data. Many cases of RRS activation occurred in the outpatient department, including severe cases. Although issues such as vital sign measurement remain, the RRS can serve as a patient safety system in the outpatient department. However, the results of this study may not be generalisable to the outpatient departments of all the hospitals. In future, the RRS outcome indicators in the outpatient department need to be clarified and the effectiveness evaluated.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRedit authorship contribution statement

Takeshi Aoyama: Conceptualization, Formal analysis, Methodology, Project administration, Validation, Visualization, Writing - original draft, Writing - review & editing. **Isao Tsuneyoshi:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Validation, Visualization, Writing - review & editing. **Takanao Otake:** Conceptualization, Methodology, Validation, Writing - review & editing. **Kazuo Ouchi:** Conceptualization, Methodology, Validation, Writing - review & editing. **Yuta Kawase:** Conceptualization, Methodology, Validation, Writing - review & editing. **Masayasu Arai:** Conceptualization, Methodology, Validation, Writing - review & editing. **Naoki Shibata:** Methodology, Validation, Writing - review & editing. **Shinsuke Fujiwara:** Conceptualization, Data curation, Methodology, Project administration, Supervision, Validation, Writing - review & editing. **Shigeki Fujitani:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Validation, Visualization, Writing - review & editing.

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Appendix A.

In-Hospital Emergency Registry in Japan collaborators

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