# The Impact of Rapid Response Team on Outcome of Patients Transferred From the Ward to the ICU: A Single-Center Study*

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**Objectives:** To determine the impact of rapid response team implementation on the outcome of patients transferred from the regular hospital ward and nonward locations to the ICU.

**Design:** Retrospective before–after cohort study.

**Setting:** The study was performed in two ICUs, one surgical and one medical, of a tertiary medical center.

**Patients:** We included 4,890 patients transferred from the hospital ward to two ICUs and 15,855 patients admitted from nonward locations.

**Interventions:** None.

**Measurements and Main Results:** Data on each patient were abstracted from the Acute Physiology and Chronic Health Evaluation III and the administrative hospital and rapid response team databases. The study period was divided into pre–rapid response team and rapid response team. A 24/7 critical care consult service and cardiac arrest teams were available for ward patient care during both periods. A total of 20,745 patients were admitted to the two study ICUs, of whom 4,890 were from the ward (2,466 and 2,424 during the pre–rapid response team and rapid response team periods, respectively). The first ICU day severity of illness was higher for the pre–rapid response team period. A multiple logistic regression model that included predicted mortality as a covariate suggested that availability of rapid response team was associated with an increased risk of hospital death in patients transferred to the ICU from the regular ward, odds ratio (95% CI) of 1.273 (1.089–1.490). For the nonward patients, the availability of rapid response team was similarly associated with increased risk of death. The ICU length of stay was shorter during the rapid response team period both in ward transfer and in nonward transfer patients.

**Conclusions:** Rapid response team implementation is associated with increased numbers of ICU admissions and rates, and transfer from the ward of less severely ill patients. However, rapid response team implementation did not improve the severity-of-illness-adjusted outcome of patients transferred from the ward. Implementation of rapid response team in an institution with a 24/7 ICU consult service may have unforeseen costs without obvious benefit. Our findings highlight that institutions should evaluate the impact of rapid response team on patient outcome and make modifications specific to their practices. (*Crit Care Med* 2013; 41:2284–2291)

**Key Words:** critical care; guideline adherence; hospital mortality; hospital rapid response team; quality of healthcare

Despite conflicting evidence, rapid response teams (RRTs) are widely used in several countries. In its 2005 campaign to save 100,000 and protect 5 million lives from harm, the Institute for Healthcare Improvement in the United States mandated the deployment of RRT in all hospitals agreeing to participate in this initiative (1, 2). In its 2008 National Patient Safety Goals, the Joint Commission suggested a methodology to enable healthcare staff members to directly request additional assistance from other individuals when the patient's condition appears worsening (3). However, the results of the studies on RRT are conflicting, and the conclusions based on meta-analyses are inconclusive (4–6). Although randomized clinical trials are appropriate to study the effect of a specific drug or procedure, they may not be appropriate to study complex systems such as RRTs. Because the RRT concept is widely accepted in current practice, randomized clinical trials may be difficult at this time (7).

Several studies, most of them based on "before–after" designs, have investigated the impact of RRTs (6). The main outcomes of interest of these studies were hospital mortality and the prevalence of hospital-wide cardiopulmonary arrests.

*See also p. 2436.

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Although a single-center ward randomized clinical trial from United Kingdom showed reduction of hospital mortality (8), a cluster-randomized multicenter clinical trial from Australia showed no association between patient mortality and RRT availability (9). The before–after studies similarly demonstrated conflicting results. Some showed a decrease in mortality (10–15), whereas others showed no change (16–19). To our knowledge, there is only one publication that demonstrated RRT to be associated with increased risk of death in medical patients and a decreased risk of death in surgical patients (20).

Before the implementation of the RRT service, our hospital provided a 24/7 critical care consult service to deteriorating patients in the hospital ward. This consult service was activated by the primary service. The implementation of the RRT provided the opportunity for nonphysician healthcare providers to independently summon critical care expertise to the bedside. We undertook this retrospective study to assess the impact of the introduction of an RRT service primarily on the outcome of patients transferred from the wards to the ICU. We hypothesized that the patients transferred during the RRT period would have lower severity of illness and lower severity-adjusted hospital mortality. We also aimed to look at the impact of RRT on non-ward-transfer ICU patients because ICU personnel staff the RRT.

## METHODS

### Design

This retrospective study was performed at Saint Marys Hospital, one of the two Mayo Medical Center hospitals, in Rochester, MN. The Institutional Review Board approved the study.

### Patients and Setting

The primary objective of this study was to determine the impact of RRT implementation on the outcome of patients transferred from the hospital ward to two adult ICUs. The secondary objective of the study was to determine the impact of RRT on the outcome of nonward patients transferred to two ICUs. The nonward locations included the emergency department, operating room, and other hospitals. We excluded patients who refused the review of their medical records for research and children less than 18 years old. Saint Marys Hospital is licensed for 1,265 inpatient beds. The hospital has one coronary care unit, one cardiovascular surgical ICU, one transplant ICU, one trauma/general surgery ICU, one neuroscience ICU, and the two study ICUs (one medical and one surgical). There were also one pediatric ICU and one neonatal ICU. The two study ICUs participated in the Acute Physiology and Chronic Health Evaluation (APACHE) III database during both periods of the study. The study ICUs were a medical ICU with 24 beds and a 20-bed surgical ICU to which patients with vascular, thoracic, orthopedic, urologic, or otorhinolaryngologic problems were admitted. Overflow medical patients were usually transferred to the surgical ICU. The RRT was introduced to the hospital for the first time on September 14, 2006, and rolled out to the whole hospital by March 16, 2007. The pre-RRT period included from August 14, 2003, to September 13, 2006, and the RRT period from March 16, 2007, to September 30, 2009. The RRT introduction period, from September 14, 2006, to March 16, 2007, was excluded.

The hospital was staffed 24 hours a day by hospitalists, residents/fellows, and/or clinical nurse practitioners and physician assistants. Surgical teams were primarily responsible for surgical patients but had 24/7 access to medical consult services (internal medicine, cardiology, nephrology, etc). The two study ICUs were covered by in-house residents and fellows 24/7 during both study periods. First- and third-year internal medicine residents rotated in the medical ICU during both study periods. The third-year residents had only 1 month of previous ICU experience before July 2006 compared with 2 months after July 2006 (21). Additionally, in-house 24/7 attending staff coverage was available in the study ICUs during the RRT period compared with night home call during the pre-RRT period (22).

### RRT

The RRT included one intensivist, one critical care fellow, one critical care–registered nurse, and one respiratory therapist. Each of these individuals worked in one of the two study ICUs. The RRT calling criteria included the following:

1) Concern by a staff member about a patient's condition
2) Acute and persistent decline in pulse oximeter oxygen saturation < 90%
3) Acute and persistent change in heart rate of < 40 or > 130 beats per minute
4) Acute and persistent change in systolic blood pressure < 90 mm Hg
5) Acute and persistent change in respiratory rate < 10 or > 28 breaths per minute
6) Acute chest pain suggestive of myocardial ischemia
7) Acute and persistent change in conscious state (including agitated delirium)
8) New onset of symptoms suggestive of stroke.

"Acute" was defined as new and/or unexpected.

### Data Collection

The main data were abstracted from the institutional APACHE III database, as previously described (23). Additional data including information regarding hospital admissions and deaths, and RRT calls were obtained from the hospital administration and RRT databases. Information about cardiac arrest calls was available for a limited part of the study period. We obtained the ICU type (surgical or medical), demographics (race, gender, and age), APACHE III comorbidities, use of invasive mechanical ventilation, ICU admission diagnoses, Acute Physiology Score (APS), APACHE III score and predicted probability of hospital death, ICU and hospital length of stay, and ICU and hospital discharge status (alive or dead). APS, APACHE III score, and APACHE III predicted mortality rate were calculated as described in the literature (24).

### Data Analyses and Statistics

Continuous data were summarized as mean ± SD or median (interquartile range [IQR]) for skewed data. Categorical data were summarized as percentages. Student *t* test, or Mann-Whitney *U* test for skewed data, was used to compare continuous data among groups. Chi-square test was used to compare categorical variables. We developed a multiple logistic regression model by entering APACHE III predicted mortality and RRT period as predictor variables and hospital mortality as the outcome variable. For each of the predictor variables included in the model, the odds ratio (OR) and 95% CI were calculated; *p* values less than 0.05 were considered statistically significant. Although our primary objective was to focus on patients transferred from the hospital ward to the ICU, we included patients admitted from the emergency department, operating room, and other hospitals separately for our secondary objective. All statistical analyses were performed using PASW Statistics 18, SPSS Inc (Chicago, IL) and MedCalc Software (version 12.2.1, Mariakerke, Belgium).

## RESULTS

### Hospital Data

The total number of hospital admissions was 183,200 during the pre-RRT and 146,090 during the RRT period. The daily hospital admission rate was 162.7 (95% CI, 162.1–163.5) patients during the pre-RRT period compared with 157.3 (95% CI, 156.5–158.1) during the RRT period ($p < 0.001$). There were 2,940 hospital deaths (1.61% [95% CI, 1.55–1.66%]) during the pre-RRT period compared with 2,250 (1.75% [95% CI, 1.68–1.82%]) during the RRT period ($p = 0.002$).

### ICU

During the two study periods, a total of 20,745 patients were admitted to the two study ICUs, 10,700 and 10,045 during the pre-RRT and RRT periods, respectively (**Fig. 1**). The study ICUs' admission rate was 58.4 (95% CI, 57.3–59.5) per 1,000 hospital admissions during the pre-RRT period compared with 68.8 (95% CI, 67.4–70.1) during RRT period ($p < 0.001$). The daily admission rate to these two ICUs was 9.5 (95% CI, 9.3–9.7) patients for the pre-RRT period compared with 10.8 (95% CI, 10.6–11.0) for the RRT period ($p < 0.001$). Of all patients admitted to the ICU, 11,442 (55.2%) were male and 18,667 (90%) white. Patient mean (SD) age was 63.3 (18.2) years. A total of 12,009 patients (57.9%) were admitted to the study medical ICU and 8,736 (42.1%) to the study surgical ICU. The source of admission was the ward in 4,890 (23.6%) patients and other patient units (emergency department, operating room, or other hospitals) in 15,855 (76.4%) patients. There were no statistically significant differences between the ward and the nonward admissions in race (90% Caucasian in both groups) or gender (54.1% of ward transfers were male vs 55.5% of nonward admissions). The ward transfers were older (mean [SD] age, 66.4 [16.6] vs 62.3 [18.6] years for nonward transfer admissions, $p < 0.001$). The severity of illness measured by APS (median [IQR], 43 [30–58] vs 35 [24–50]), APACHE III score (median [IQR], 58 [44–75] vs 48 [34–65]), and predicted mortality rate (median [IQR], 15.4 [6.4–34.3]% vs 5.7 [1.7–16.1]%) was higher for the ward transfer group ($p < 0.001$ for all).

### Transfers From Ward

Of the 10,700 patients admitted during the pre-RRT period, 2,466 (23.0%) patients were transferred from the regular hospital ward compared with 2,424 of the 10,045 (24.1%) patients during the RRT period ($p = 0.066$). The daily ward to the two ICU transfer rate was 2.19 (95% CI, 2.10–2.28) patients for the pre-RRT period compared with 2.61 (95% CI, 2.51–2.72) for the RRT period ($p < 0.001$). Of the 4,890 transfers, 1,747 of 2,466 (70.8%) patients were admitted to the medical ICU during the pre-RRT period compared with 1,596 of 2,424 (65.8%) during the RRT period ($p < 0.001$). None of the 1,324 surgical patients was admitted to the medical ICU compared with 223 of 3,266 medical patients (6.3%) admitted to the surgical ICU ($p < 0.001$). Of the 223 medical patients transferred from the ward to the surgical ICU, 73 (a total of 1,820 medical patients, 4%) were transferred during the pre-RRT period compared with 150 (of 1,746 patients, 8.6%) admitted during the RRT period ($p < 0.001$).

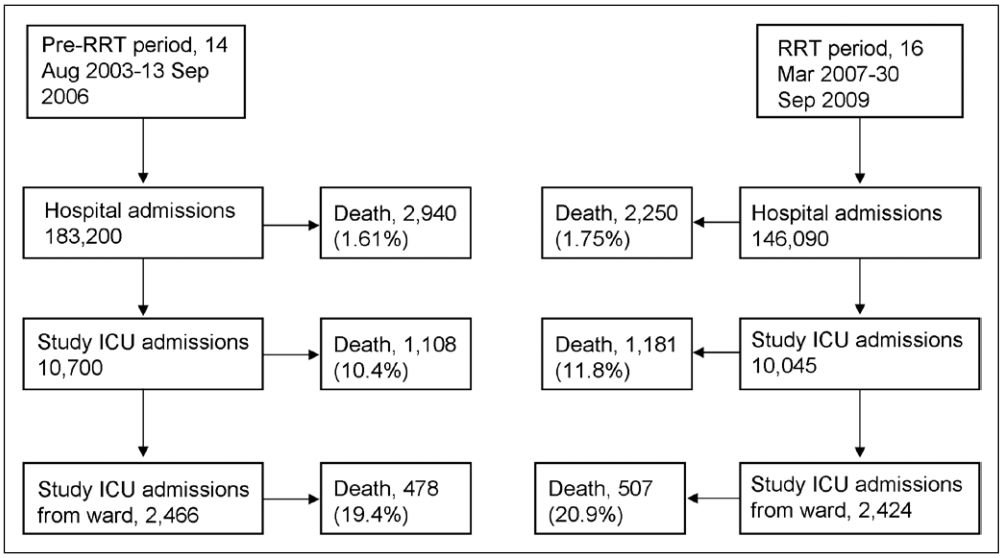


**Figure 1.** Patient flow during the two study periods. RRT = rapid response team.

### Differences Between Transfers During the Pre-RRT and RRT Periods

The proportion of whites transferred to the ICU was higher

**TABLE 1. Ward to ICU Transfer Patient Characteristics During the Two Study Periods**

| Characteristics | Pre-RRT Period, *n* = 2,466 | RRT Period, *n* = 2,424 | *p* |
|---|---|---|---|
| Age, mean (SD) | 66.0 (16.7) | 66.7 (16.5) | 0.131 |
| Female gender | 1,156 (46.9%) | 1,088 (44.9%) | 0.162 |
| Caucasian race | 2,259 (91.6%) | 2,147 (88.6%) | < 0.001 |
| Reason for ICU admission | | | 0.022[a] |
| Respiratory | 916 (37.1%) | 914 (37.7%) | |
| Cardiovascular | 851 (34.5%) | 885 (36.5%) | |
| Gastrointestinal | 340 (13.8%) | 263 (10.8%) | |
| Neurologic | 117 (4.7%) | 132 (5.4%) | |
| Genitourinary | 115 (4.7%) | 104 (4.3%) | |
| Metabolic/endocrine | 62 (2.5%) | 69 (2.8%) | |
| Hematologic | 23 (0.9%) | 32 (1.3%) | |
| Musculoskeletal | 28 (1.1%) | 18 (0.7%) | |
| Trauma | 14 (0.6%) | 7 (0.3%) | |

RRT = rapid response team.
[a]*p* value comparing the frequency of reasons for ICU admission between the pre-RRT and the RRT groups.

during the pre-RRT period (**Table 1**). The first-day severity of illness, measured by the APACHE III prognostic model, was lower during the RRT period (**Table 2**).

The most common reasons for ICU admission during both periods of the study were derangements of the respiratory and cardiovascular systems (Table 1). There were no statistically significant differences in the frequency of APACHE III comorbidities between the two groups (Table 2). The mean (SD) APACHE III predicted hospital mortality rate was 25.1 (24.5)% for the pre-RRT group compared with 23.0 (22.8)% for the RRT period ($p = 0.002$).

The median (IQR) ICU and hospital length of stay were 3 (2–5) and 11 (6–22) days, respectively. The median (IQR) ICU length of stay was slightly longer during the pre-RRT period (**Table 3**). During the pre-RRT period, 795 patients (32.2%) received mechanical ventilation compared with 792

**TABLE 2. Acute Physiology and Chronic Health Evaluation III Severity Measures and Comorbidities of Ward to ICU Transfer Patients During the Study Periods**

| Severity Measures and Comorbidities | Pre-RRT Period, *n* = 2,466 | RRT Period, *n* = 2,424 | *p* |
|---|---|---|---|
| APS, median (IQR) | 44.0 (30.0–60.0) | 41.0 (29.0–57.0) | <0.001 |
| APACHE III score, median (IQR) | 59.0 (44.0–77.0) | 58.0 (43.0–74.0) | 0.018 |
| APACHE III predicted mortality | | | |
| Median (IQR) | 16.1 (6.7–36.1)% | 14.9 (6.1–32.5)% | 0.015 |
| Mean (SD) | 25.1 (24.5)% | 23.0 (22.8)% | 0.002 |
| Comorbidity | | | 0.532 |
| None | 1,875 (76.0%) | 1,854 (76.5%) | |
| Leukemia/multiple myeloma | 275 (11.2%) | 261 (10.8%) | |
| Solid tumor/metastasis | 172 (7.0%) | 151 (6.2%) | |
| Hepatic failure | 62 (2.5%) | 68 (2.8%) | |
| Hepatic cirrhosis | 47 (1.9%) | 55 (2.3%) | |
| Lymphoma | 27 (1.1%) | 32 (1.3%) | |
| Immunocompromise | 8 (0.3%) | 3 (0.1%) | |

APACHE = Acute Physiology and Chronic Health Evaluation, RRT = rapid response team.

**TABLE 3. Differences in Length of Stay and Mortality in Ward to ICU Transfer Patients Between the Pre-Rapid Response Team (RRT) and RRT Groups**

| Outcome | Pre-RRT Period, *n* = 2,466 | RRT Period, *n* = 2,424 | *p* |
|---|---|---|---|
| ICU length of stay, median (IQR), days | 3 (2–5) | 3 (2–4) | <0.001 |
| Hospital length of stay, median (IQR), days | 11 (6–22) | 11 (6–21) | 0.337 |
| ICU mortality | 259 (10.5%) | 247 (10.2%) | 0.719 |
| Hospital mortality | 478 (19.4%) | 507 (20.9%) | 0.182 |

RRT = rapid response team.

(32.7%) during the RRT period ($p = 0.745$). The ICU and hospital mortality rates for the two groups were similar (Table 3). Multiple logistic regression analysis showed that ICU admission during the RRT period was associated with increased risk of death with OR (95% CI) of 1.273 (1.089–1.490) (**Table 4**). The increased risk of death was noted both in the surgical and medical ICUs.

For patients admitted from the emergency department, operating room, or another hospital, the hospital mortality rate was higher and the ICU and hospital length of stay shorter during the RRT period (**Table 5**). However, the predicted mortality rate was similar between the pre-RRT and the RRT groups. Similar to the ward transfer group, multiple logistic regression analysis showed the RRT period was associated with increased risk of hospital death for nonward transfer patients (**Table 6**).

### RRT Calls

There were 1,498 RRT calls and 143,542 hospital discharges during the second period. The RRT call rate was 10.44 (95% CI, 9.91–10.98) per 1,000 hospital discharges. During the first 1 year of the RRT period, there were 530 total RRT calls and 1.45 (95% CI, 1.33–1.58) daily calls compared with 675 total and 1.84 (95% CI, 1.71–1.99) daily calls during the last year ($p < 0.001$). Excluding 19 pediatric patients (age less than 18 yr) and 22 patients (visitors not clearly registered in the RRT database), adequate information about RRT calls was available in 1,457 adults. Of the 2,424 patients transferred from the ward to the ICU during the second period of the study, 844 (34.8%) had RRT calls. RRT was activated in 718 of 1746 medical patients transferred to the ICU (41.1%) compared with 126 of 678 surgical patients (19.6%; $p < 0.001$). Of the patients who had an RRT call, an additional 75 (5.1%) were admitted to the

**TABLE 4. Multiple Logistic Regression Model of Hospital Mortality in Ward to ICU Transfer Patients Accounting for Predicted Mortality and Rapid Response Team Period**

| Predictor Variable | Odds Ratio (95% CI) | *p* |
|---|---|---|
| All patients | | |
| Predicted hospital mortality, % | 1.042 (1.039–1.045) | <0.001 |
| Study period | | |
| Pre-RRT | Reference | |
| RRT | 1.273 (1.089–1.490) | 0.002 |
| Surgical ICU | | |
| Predicted hospital mortality, % | 1.048 (1.041–1.055) | <0.001 |
| Study period | | |
| Pre-RRT | Reference | |
| RRT | 2.285 (1.548–3.375) | <0.001 |
| Medical ICU | | |
| Predicted hospital mortality, % | 1.040 (1.036 – 1.044) | <0.001 |
| Study period | | |
| Pre-RRT | Reference | |
| RRT | 1.199 (1.006–1.429) | 0.043 |

RRT = rapid response team.

**TABLE 5. Severity of Illness, Lengths of ICU and Hospital Stay, and Mortality of Patients Admitted From the Emergency Department, Operating Rooms, and Other Institutions**

| Severity of Illness | Pre-RRT Period, *n* = 8,234 | RRT Period, *n* = 7,621 | *p* |
|---|---|---|---|
| APS, median (IQR) | 35 (24–51) | 34 (24–49) | <0.001 |
| APACHE III, median (IQR) | 49 (34–66) | 48 (34–64) | 0.068 |
| Predicted mortality, median (IQR), % | 5.8 (1.7–16.7) | 5.6 (1.8–15.5) | 0.138 |
| ICU length of stay, median (IQR), days | 2 (2–4) | 2 (2, 3) | <0.001 |
| Hospital length of stay, median (IQR), days | 6 (3–12) | 5 (2–10) | <0.001 |
| ICU mortality | 355 (4.3%) | 376 (4.9%) | 0.062 |
| Hospital mortality | 630 (7.7%) | 674 (8.8%) | 0.006 |

RRT = rapid response team, IQR = interquartile range.

coronary care unit, 51 (3.5%) to the neuroscience ICU, and 439 (29.8%) changed no location. We were able to obtain partial data on cardiac arrest in the wards during the study periods. From January 1, 2006, to September 30, 2006, there were 186 cardiopulmonary arrest calls, daily rate of 0.68 (95% CI, 0.59–0.79) compared with 143 cardiopulmonary arrest calls, daily rate of 0.53 (95% CI, 0.44–0.62) from January 1, 2009, to September 30, 2009 ($p = 0.018$).

## DISCUSSION

### Main Findings

In this retrospective study of two ICUs of a tertiary academic medical center, the deployment of an RRT was an independent risk factor for hospital death of patients transferred from the hospital ward to the ICU. Although the overall daily hospital admission rate was lower, the daily admission rate to the study ICUs was higher during the RRT period. The severity of illness was lower in both ward transfer and nonward transfer patients during the RRT period. The ICU, but not the hospital, length of stay was shorter during the RRT period. During the second part of our study, the RRT was called only for the minority of patients transferred from the ward. In patients admitted from nonward locations, the RRT period was associated with increased mortality risk and shorter ICU and hospital length of stays. Although our data are incomplete, we saw a reduction in the ward cardiopulmonary arrest calls during the RRT period.

**TABLE 6. Multiple Logistic Regression Analysis of Hospital Mortality for Patients Admitted From the Emergency Department, Operating Rooms, and Other Institutions**

| Predictor Variable | Odds Ratio (95% CI) | *p* |
|---|---|---|
| Hospital predicted mortality in % | 1.064 (1.061–1.066) | <0.001 |
| Study period | | |
| Pre-RRT | Reference | |
| RRT | 1.427 (1.246–1.633) | < 0.001 |

RRT = rapid response team.

### Patient Outcome

Our study shows mixed patient outcome results associated with RRT: increased mortality risk and reduced ICU length of stay. To our knowledge, this study is the second one showing possible adverse effect of RRT implementation on patient outcome (20). Previous studies examining the role of RRT focused on the cardiac arrest and hospital mortality rates as the main outcome measures. Most of the studies did not show a statistically significant impact on the cardiac arrest rate. Of the two clinical trials with prospective components, RRT was associated with decreased mortality in the study by Priestley et al (8), but not in the study by Hillman et al (9). Only one study showed an association between increased risk of death and RRT implementation (20). Although we did not find mortality benefit associated with RRT, our data do not refute its potential benefits. The fact that the RRT was activated only in the minority of patients transferred from the floor may account for part of the increased mortality. Although our data were incomplete, the cardiopulmonary arrest call rates declined during RRT period compared with the pre-RRT one. This finding is similar to most of the other studies, including a multicenter randomized trial (4, 6, 9)

### Severity of Illness

In our study, the severity of illness (measured by APS, APACHE III score, and APACHE III predicted mortality) was lower during the RRT period in both the ward and the nonward transfer patients. This may be due to the fact that the patients were overall less sick, or the RRT system and the education associated with it led to earlier identification of deteriorating ward patients and thus to less severity of illness at ICU admission. The emergency department, other patient units such as the operating and recovery rooms, and referring hospitals may have benefited from RRT education as well. The timely

identification of deteriorating patients provides an opportunity for early intervention and thus improvement of patient outcome. Chen et al (25) have highlighted the importance of early RRT calls in preventing serious adverse events such as cardiac arrests and unexpected deaths.

### RRT Calls

During the second part of our study, only the minority of patients had RRT calls before their transfer to the ICU. However, the daily RRT call rate increased during the last year of the study. There may be dose-dependent relationship between the number of RRT calls and good outcome (25). We hope the reorganization of our RRT system with subsequent placement of earlier calls may improve patient outcome. As our experience with RRT and the proportion of RRT calls in our institution increase, we may see reversal of the increased risk of death we observed in the current study.

### Mechanisms to Explain Our Findings

There are multiple potential explanations for the severity-adjusted increase in hospital mortality during the RRT period of our study. Independent of RRT implementation, the quality of ward and ICU care may have changed because of changes in ICU models of staffing (e.g., alterations in resident work hours and work patterns) or alterations in care processes. As a result of RRT implementation, admission of many patients with lower severity of illness may have diverted the attention of ICU personnel from those with higher illness severity. The RRT is staffed by ICU personnel, thus removing them from patient care in the ICU for variable periods of time. The unintended consequence of detaching the primary care providers from their patients during the RRT process and diversion of the relatively scarce ICU resources during the RRT period may have compromised the potential benefits of RRT. The ICU staffing may not have been adequately adjusted for RRT calls. The existence of a similar system to address critical illness in the ward before RRT was deployed may have diluted its potential benefits.

### Strengths and Limitations

The main strength of our study is the highlighting of unintended potential adverse effects of RRT implementation. However, the study has several limitations. It is a single-center retrospective study with a before–after design. Most of the study data are derived from the ICU APACHE III database. We had limited data to address the impact of RRT on the overall hospital mortality, cardiac arrest rate, or other pertinent patient outcomes. There is also the possibility that the use of APACHE III prognostication may not have been accurate during the later periods because of alterations in case-mix over time (26). The variables we included in the multiple logistic regression models were the ones that were available in the APACHE III database. This may have led to the exclusion of other potentially important prognostic factors. The fact that only 34.8% of the ward transfers had RRT calls during the RRT period also makes it difficult to assess the exact impact of the intervention.

### Clinical Implications

The appropriate implementation of an RRT system requires close collaboration between ward and ICU healthcare providers and a clearly defined role for the RRT. The main goal of the RRT is to prevent irreversible organ damage. Patients at low risk for critical illness should be initially managed by the primary care provider in the ward. With the current RRT system in an institution such as ours, the primary care physicians may become detached from their primary care roles. One RRT system may not fit all. Despite the widespread deployment of RRTs, each institution has to pause and assess the need for RRT, assess its impact on patient outcome, and modify the system to meet the local needs.

## CONCLUSIONS

Our study has mixed results. RRT implementation is associated with increased numbers of ICU admissions and rates, and transfer from the ward of less severely ill patients. Patients transferred to the ICU from the ward had higher severity of illness compared with those admitted from other sources. The cardiopulmonary arrest rate was lower during the RRT period. However, RRT implementation did not improve the severity-of-illness-adjusted outcome of patients transferred from the ward. Implementation of RRT in an institution with a 24/7 ICU consult service may have unforeseen costs without obvious benefit. Our findings highlight that institutions should evaluate the impact of RRT on patient outcome and make modifications specific to their practices. We agree with a previously published statement that evaluating an already-established practice is as difficult as servicing a car in motion (7). However, we see no alternatives to well-designed studies to resolve this issue. In the meantime, professional organizations and regulatory agencies should consider modifications to soften their recommendations regarding deployment of RRT.

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