"Deterioration to Door Time": An Exploratory Analysis of Delays in Escalation of Care for Hospitalized Patients

Christopher B. Sankey, MD[1,2], Gail McAvay, PhD[3], Jonathan M. Siner, MD[4], Carol L. Barsky, MD, MBA[5], and Sarwat I. Chaudhry, MD[1,2]

[1]Section of General Medicine, Department of Internal Medicine, Yale University School of Medicine, New Haven, CT, USA; [2]Yale-New Haven Hospital, New Haven, CT, USA; [3]Section of Geriatric Medicine, Department of Internal Medicine, Yale University School of Medicine, New Haven, CT, USA; [4]Section of Pulmonary, Critical Care and Sleep Medicine, Department of Internal Medicine, Yale University School of Medicine, New Haven, CT, USA; [5]Patient Safety and Quality, Hackensack University Medical Center, Hackensack, NJ, USA.

BACKGROUND: Timely escalation of care for patients experiencing clinical deterioration in the inpatient setting is challenging. Deterioration on a general floor has been associated with an increased risk of death, and the early period of deterioration may represent a time during which admission to the intensive care unit (ICU) improves survival. Previous studies examining the association between delay from onset of clinical deterioration to ICU transfer and mortality are few in number and were conducted more than 10 years ago.

OBJECTIVE: We aimed to evaluate the impact of delays in the escalation of care among clinically deteriorating patients in the current era of inpatient medicine.

DESIGN AND PARTICIPANTS: This was a retrospective cohort study that analyzed data from 793 patients transferred from non-intensive care unit (ICU) inpatient floors to the medical intensive care unit (MICU), from 2011 to 2013 at an urban, tertiary, academic medical center.

MAIN MEASURES: "Deterioration to door time (DTDT)" was defined as the time between onset of clinical deterioration (as evidenced by the presence of one or more vital sign indicators including respiratory rate, systolic blood pressure, and heart rate) and arrival in the MICU.

KEY RESULTS: In our sample, 64.6 % had delays in care escalation, defined as greater than 4 h based on previous studies. Mortality was significantly increased beginning at a DTDT of 12.1 h after adjusting for age, gender, and severity of illness.

CONCLUSIONS: Delays in the escalation of care for clinically deteriorating hospitalized patients remain frequent in the current era of inpatient medicine, and are associated with increased in-hospital mortality. Development of performance measures for the care of clinically deteriorating inpatients remains essential, and timeliness of care escalation deserves further consideration.

KEY WORDS: inpatient clinical deterioration; delays; care escalation; care transitions; timeliness.

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INTRODUCTION

Timely escalation of care for patients experiencing clinical deterioration in the inpatient setting continues to present significant challenges to clinicians and health systems. Clinical deterioration that occurs after admission to a general floor (e.g., non-critical care setting) has been associated with an increased risk of death.[1] The early period of deterioration may represent a time at which admission to the intensive care unit (ICU) is associated with improved survival,[2] particularly among patients who experience deterioration after admission to the hospital.[3] The existing studies examining the relationship between the delay from onset of clinical deterioration to ICU transfer and mortality were conducted over a decade ago,[4,5] did not examine the role of delays in care escalation,[6] or were restricted to the first 48 h of hospitalization,[7] collectively precluding a contemporary understanding of the impact of such delays throughout a hospital stay.

To evaluate the current impact of delays in the escalation of care for clinically deteriorating inpatients, we examined the time between onset of clinical deterioration and arrival to a higher level of care in a large, urban, academic tertiary care hospital. We assessed the relationship between delays in transfer and in-hospital mortality, adjusting for demographic and clinical characteristics. We hypothesized that despite advances in processes of care for inpatient clinical deterioration, delays in escalation of care remain associated with increased mortality. These analyses can provide insight about whether contemporary management strategies have translated into timely escalations of care for deteriorating patients in the hospital setting, and generate hypotheses as to why delays occur that can be evaluated in future studies.

METHODS

Setting and Data Source

This retrospective cohort study was performed over a 25-month period (1 September 2011 through 30 September 2013) at Yale-New Haven Hospital (YNHH). YNHH is an academic tertiary medical facility in New Haven, Connecticut with a 1544 bed capacity and 88,000 discharges annually. The database utilized to perform this study was developed by merging a data set containing information about patients' Rothman Index[8] (a severity of illness score utilized for all inpatients at YNHH) with a data set from the hospital's bed management system. Both data sets are continually updated to reflect the most recently updated information.

Definitions and Outcome Measurements

We defined the "deterioration to door time (DTDT)" as the time between documented onset of clinical deterioration (in the electronic medical record) and a patient's arrival to the medical intensive care unit (MICU). This measurement has been termed "score to door time" in a previous study.[9] As our focus in this investigation is the occurrence of clinical deterioration and the timeliness of care escalation, we selected the title "deterioration to door time" to indicate the time between the first occurrence of clinical deterioration and transfer to the ICU. We did not aim to devise a new score for clinical deterioration, and while we did examine a particular scoring algorithm (Rothman Index), this was not used as a "trigger" for our assessment of the interval of time between initial physiologic deterioration and ICU transfer. Clinical deterioration was defined by the following vital sign abnormalities: respiratory rate greater than 28 or less than eight breaths per minute, systolic blood pressure greater than 200 or less than 90 mmHg, and pulse greater than 130 or less than 40 beats per minute. These vital signs were chosen due to ubiquity of measurement and the availability of these clinical variables in our data set. The cut-points selected for each vital sign were informed by the YNHH rapid response team (RRT) activation criteria, explicitly chosen to select for "sicker" patients experiencing true clinical deteriorations, and are consistent with those in other studies.[10–13] While the onset of clinical deterioration required only a single abnormal vital sign (the earliest), in some cases, multiple abnormal vital signs were simultaneously present and/or developed during the interval between initial abnormality and MICU transfer. Other common types of clinical deterioration (seizure, hemorrhage, alteration in mental status) were not included in our analysis because information was not present in our administrative data sets.

Characteristics of patients experiencing clinical deterioration, including age, sex, race, and discharge diagnosis, were collected from the electronic medical record. Severity of illness was collected at the time of initial clinical deterioration based on the Rothman Index (RI), a measure of illness acuity that incorporates 26 clinical variables including vital signs, laboratory results, cardiac rhythms, and nursing assessments into a single score.[8,14–16] An RI value of less than or equal to 30 was used as a marker of severe illness.[16] The primary outcome assessed was 30-day in-hospital mortality, adjusted and un-adjusted.

Patient Selection

We defined an escalation to a higher level of care as any transfer into the MICU or medical step-down unit at YNHH, both of which are managed by teams separate from those on the general medical floors. Together, these units are comprised of 51 beds, and arrival in a higher level of care for the purposes of our analysis was identified by change in a patient's location to one of these beds. For consistency of terminology in this study, we have collectively referred to this composite of beds as "the MICU." Nursing ratios at our institution differ markedly between the MICU (ranging from 1:1 to 1:3) and the general floor (1:5 to 1:6), as does the frequency of vital sign monitoring (every 1–4 h in the MICU versus every 4–8 h on the general floor) and continuous cardiac monitoring ("telemetry"), which is provided for all MICU patients and only for select patients on the general floor.

The patient inclusion process is summarized in Fig. 1. All adult inpatients greater than 18 years old transferred from non-ICU inpatient settings to the MICU were evaluated for inclusion. Transfers that originated from the emergency room (ER) or any other intensive care unit were excluded in order to identify patients experiencing clinical deterioration on a general floor. Because our goal was to identify timeliness of care escalation following vital sign abnormalities, patients who did not have documentation of a specified indicator of clinical deterioration prior to transfer were not included. To better understand the clinical circumstances of such transfers, we examined the medical records of approximately 5 % of patients transferred without a documented indicator of clinical

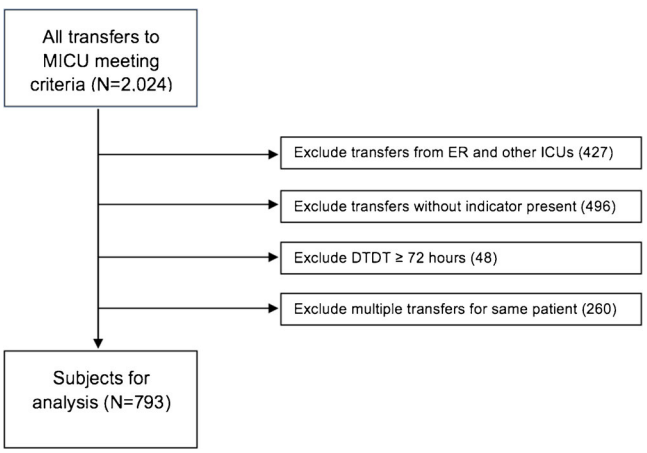

Figure 1. Patient inclusion process. ***Abbreviations*****: *MICU* medical intensive care unit, *ER* emergency room, *DTDT* deterioration to door time.**

deterioration, and confirmed that these transfers primarily occurred due physiologic derangements (seizure, acute hemorrhage, change in mental status) that were not identified as one of our indicators. For patients who had more than one transfer during the study period, only the first was included. DTDT times of greater than or equal to 3 days (72 h) were also excluded from our analysis, as certain patient populations may have persistent stable derangements in vital signs that could potentially complicate interpretation of onset of clinical deterioration (e.g., hypotension in a stable cirrhotic patient and other "chronically critically ill" patients).

Statistical Analysis

Characteristics of the study sample and vital sign indicators of clinical deterioration were summarized as means and standard deviations, or as counts and percentages. To explore and understand the relationship between time to transfer and outcomes, we examined quintiles of patients with varying times between onset of clinical deterioration and MICU transfer as follows: 1 = 0–2.5 h, 2 = 2.6–4.5 h, 3 = 4.6–12 h, 4 = 12.1–36.5 h and 5 = 36.6–72 h. Quintiles were chosen a priori to create enough categories to more precisely characterize the shape of the relationship between DTDT and the outcome. Additionally, because previous work has suggested a 4-h cut-point to distinguish "fast" and "slow" transfers,[5,9] we describe the percentages of patients meeting these criteria as well.

The association of DTDT and in-hospital mortality was evaluated using Cox regression models, adjusting for age, sex, and severity of illness. For this analysis, we set time zero as the onset time of clinical deterioration and followed patients for up to 30 days or hospital discharge, whichever came first. Hazard ratios (HR) and 95 % confidence intervals for mortality rates in each DTDT quintile were estimated, with the reference group consisting of DTDT of 2.6–4.5 h (quintile 2) based on initial bivariate analyses showing lowest mortality rates in this group. The proportional hazards assumption was tested by using interaction terms between the time-to-event outcome and each variable in the multivariable model; the terms were retained if $p < 0.05$ after adjusting for the number of tests.

The Cox regression models were estimated using SAS version 9.3 (SAS Institute, Inc., Cary, NC), with a p value < 0.05 (two-sided) denoting statistical significance. A Chi-square tests was used to test the association between discharge diagnosis group and mortality. This study was approved by the Yale University Human Investigation Committee.

RESULTS

Patient characteristics are summarized in Table 1. Nearly half were less than 65 years of age, approximately half were female, and nearly 29 % of the sample was of non-white race. The five most common discharge diagnosis categories were pulmonary (including pneumonia, pulmonary embolism, pleural effusion, pneumothorax, respiratory failure, asthma/COPD), sepsis, gastrointestinal (including cirrhosis and associated complications, peptic/duodenal ulcer disease, gastrointestinal bleeding, intestinal obstruction/perforation, obstructive biliary disease, pancreatitis), malignancy, and infection (excluding sepsis and pneumonia). Systolic hypotension (45.8 %), tachypnea (34.3 %), and tachycardia (20.4 %) were the most common physiologic indicators of clinical deterioration. Using the Rothman Index, approximately one-third of our sample was classified as "severely ill" (e.g., RI ≤ 30) at onset of clinical deterioration. The average length of stay on the general inpatient floor was 18.9 days (range 1–221), and the mean length of stay in the ICU was 103 h (range 0.5–977). In our sample, 64.6 % had DTDTs greater than or equal to 4 h.

The overall in-hospital mortality for our study was 19.8 %, while the observed mortality in patients without vital sign indicators of clinical deterioration prior to ICU transfer was only 8 %. The relationship between DTDT and in-hospital mortality is summarized in Table 2. Mortality was

Table 1 Patient Characteristics ($N = 793$)

	N (%)
Age (years):	
218–64	370 (46.7)
65–74	183 (23.1)
75–99	240 (30.3)
Female	390 (49.2)
Non-White Race	228 (28.8)
Indicators of Clinical Deterioration Prior to MICU Transfer:	
Systolic Blood Pressure < 90 mmHg	363 (45.8)
Systolic Blood Pressure > 200 mmHg	36 (4.5)
Respiratory Rate < 8 breaths per min	4 (0.5)
Respiratory Rate > 28 breaths per min	271 (34.3)
Heart Rate < 40 beats per min	7 (0.9)
Heart Rate > 130 beats per min	162 (20.4)
Discharge Diagnosis	
Pulmonary[a]	152 (19.2)
Sepsis[b]	130 (16.4)
Gastrointestinal[c]	110 (13.9)
Malignancy[d]	91 (11.5)
Infection[e]	60 (7.6)
Cardiac[f]	55 (6.9)
Neuro-Psychiatric[g]	54 (6.8)
Other[h]	141 (17.8)
Rothman Index (Severity of Illness)	
≤ 30	253 (31.9)
≥ 31	540 (68.1)

[a] *Includes pneumonia/pneumonitis, pulmonary embolism, pleural effusion, pneumothorax, acute/chronic respiratory failure, asthma/chronic obstructive pulmonary disease (COPD)*
[b] *Any infection with documentation of associated sepsis or septicemia*
[c] *Includes cirrhosis (all types) and associated complications (hepatic encephalopathy, spontaneous bacterial peritonitis, hepato-renal syndrome), peptic/duodenal ulcer disease, upper/lower gastrointestinal bleeding (all types), intestinal obstruction/perforation, obstructive biliary disease, acute/chronic pancreatitis*
[d] *Includes solid and liquid tumors*
[e] *All infections excluding sepsis and pneumonia*
[f] *Includes myocardial infarction, heart failure/cardiomyopathy (all types), arrhythmia (including atrial fibrillation)*
[g] *Includes stroke (all types), seizure, substance intoxication/withdrawal, accidental/intentional overdose, dementia, delirium*
[h] *Includes hematologic (non-malignant), renal/urologic, orthopedic/rheumatologic, dermatologic, endocrine diagnoses*

Table 2. Deterioration to Door Time (DTDT) and In-Hospital Mortality ($N = 793$)

DTDT	Deaths	Un-adjusted mortality HR (95 % CI)	*p* value	Adjusted mortality[a] HR (95 % CI)	*p* value
0–2.5 h	32 (19.8 %)	1.45 (0.84, 2.52)	.183	1.51 (0.87, 2.62)	0.143
2.6–4.5 h	21 (13.4 %)	Reference Group	–	Reference Group	–
4.6–12 h	24 (15.3 %)	1.11 (0.62, 1.99)	.737	1.18 (0.66, 2.13)	0.573
12.1–36.5 h	36 (22.8 %)	1.57 (0.92, 2.70)	.099	1.82 (1.06, 3.12)	0.031
36.6–72 h	44 (27.7 %)	1.64 (0.97, 2.75)	.064	1.96 (1.16, 3.31)	0.012

[a]*Cox regression model, controlling for age, sex, and severity of illness*

significantly increased beginning at a DTDT of 12.1 h after adjusting for age, gender, and severity of illness. The increased mortality seen for DTDTs of 0–2.5 h and 4.6–12 h did not reach statistical significance and may be due to chance. Mortality ranged from 75 to 84 % by discharge diagnosis group (pulmonary, cardiac, infectious, malignancy, gastrointestinal), but differences in mortality between groups were not statistically significant. The relationship between severity of illness and DTDT category is depicted in Fig. 2, demonstrating that the proportion of patients with higher illness acuity declined as the time to transfer increased. This relationship between illness severity and DTDT was statistically significant, with $p = 0.006$.

DISCUSSION

Our study demonstrates that delays in the escalation of care for clinically deteriorating patients on general medical floors are frequent, and are associated with in-hospital mortality. Our findings confirm and update those of previous investigations suggesting delays are common after the inpatient onset of clinical deterioration,[4,9] and that delays in the time from abnormal vital signs to ICU admission are associated with increased mortality.[5] The overall rate of mortality of 19.8 % in our study is consistent with that published in a previous study examining unplanned intra-hospital ICU admission.[6] In addition, the higher mortality rate observed in the 12–24 h group was not attributable to higher illness acuity, since the percentage of high acuity illness actually decreased in this late transfer group.

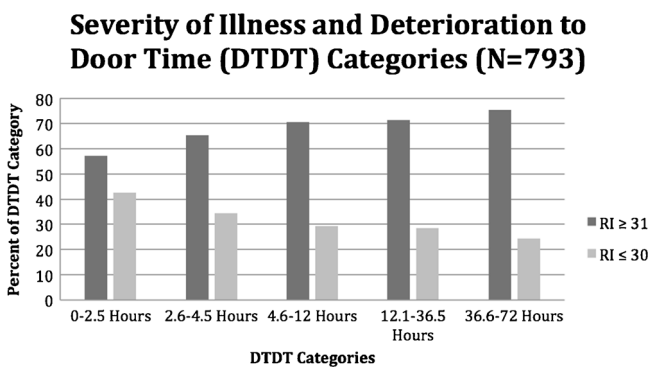

Figure 2 Severity of illness and deterioration to door time (DTDT) Categories. Rothman Index (RI) is severity of illness tool, with RI value inversely related to illness severity, and a value of 30 or less used as the cut-point for severe illness.

This investigation provides a contemporary examination of the timeliness of care escalation among clinically deteriorating inpatients and its impact on clinical outcomes. Four previous studies have collectively addressed the issues of inpatient care escalation and mortality: two[4,5] utilized data from the 1990s and included fewer than 100 patients transferred from general medical floors to an ICU, one[6] investigated the association between in-hospital transfers to a higher level of care and mortality, but did not examine the role of delays in care escalation, and one[7] was a triage study which evaluated clinical deterioration occurring immediately following admission from the emergency department. Compared with these previous studies, our investigation provides a contemporary update, as the standard process of care for inpatient clinical deterioration has evolved substantially in the last 15 years. Our study also examines a larger cohort of transfers, and investigates the role of delays as they relate to escalation of care and mortality for patients at any point during hospitalization.

Two prior investigations used a cut-point of 4 h as a distinction between "fast" and "slow" transfers; using this convention, our rate of "slow" transfers (64.6 %) was comparable to the rates of 61%[5] and 71%[9] reported previously. We did not use a single cut-point in order to examine the shape of the association between time and mortality, including the "U" shaped relationship between DTDT and mortality (that is, higher mortality with very short and longer DTDTs) and the graded, step-wise relationship between DTDT and mortality. The increased mortality in the 0–2 h DTDT group likely reflects high clinical acuity in the most clearly clinically decompensating ("crashing") patients who experienced immediate escalation and experienced poor outcomes on basis of their clinical severity. Our work extends findings from a previous study, that delays in the time from abnormal vital signs to ICU admission are associated with increased mortality[5]; however, the data in that prior study were collected nearly 20 years ago and had a small sample size (< 100). We have updated these results in the current era of increased attention to the clinically deteriorating patient. In addition, a more recent investigation examining the duration from detectable physiologic abnormality to ICU arrival ("score to door time") did not examine patient outcomes.[9]

The reasons for which delays remain numerous and correlate with increased mortality are complex, and the reason for which exploratory ("hypothesis-generating") studies such as this are necessary.[17] We postulate that there are likely system-related and patient-related factors that influence this relationship and contribute to what has come to be known as "failure

to rescue."[18,19] System-related factors may include general inpatient floor staffing models and provider–patient ratios,[20] temporal issues including the time of day and day of the week at which deterioration occurs,[21] adherence to vital sign monitoring protocols,[22] and ICU bed availability.[7,23,24] There are also cultural barriers preventing staff from calling for assistance,[25–28] and nurse/physician providers often do not accurately self-assess the quality of their care for clinically deteriorating patients.[28] Patient factors, such as severity of illness, age,[29] medical comorbidities, and the number and type of specific criteria heralding deterioration[12,13,30] may all play a role as well. Further investigation into the factors leading to delays in detection of clinical deterioration and escalation of care and the relative impact each may have on outcome is warranted.

No consensus or standards currently exist by which the care of clinically deteriorating patients can be evaluated; hence, our use of approximate quintiles of DTDT. Timeliness has been recognized by the Agency for Healthcare Research and Quality, the Institute of Medicine, and the Joint Commission as an essential component of quality medical care.[31–33] "Door-to-balloon time"[34] and "door-in to door-out time"[35] for acute myocardial infarction and "door-to-needle time"[36] for acute ischemic stroke are widely familiar national benchmarks for quality medical care that punctuate the value of timeliness. Despite such measures becoming canon in medical culture, targets for the timely detection of clinical deterioration and escalation of care for inpatients remain comparatively undeveloped. Given our results, we suggest further efforts be made to establish a validated patient-centered safety metric with respect to timeliness in recognition and escalation for clinical deterioration in inpatient settings.

Our study has important limitations. This study was conducted at a single urban hospital and may not be generalizable to other settings. We do not have information regarding interventions (e.g., volume resuscitation for hypotension or diuretic therapy for acute pulmonary edema) performed on the general floor in response to clinical deterioration, and allowed patients to remain on the general floor and avoid MICU transfer. As outlined in our methods, limitations were also present regarding availability of certain clinical variables in the data set, including patient comorbidities, other types of clinical deterioration (hemorrhage, hypoxia, change in mental status), and rapid response team (RRT) activation. We acknowledge that potential confounders/covariates may have influenced patient outcomes, including RRT involvement, antibiotic administration, respiratory therapy involvement, and others that were not available. Additionally, investigation into the relative proportions of delay attributable to the floor of origin (e.g., "failure to rescue") versus the MICU (e.g., bed availability and patient acceptance) would be informative. Our study also carries potential for "over-correcting," given that we adjusted for the RI, which also contains vital signs. However, we re-ran the data analysis without controlling for the RI and found similar results.

CONCLUSIONS

Our results indicate that delays of care for clinically deteriorating hospitalized patients remain common in the current era of inpatient medical practice and are associated with increases in in-hospital mortality. Delays in care escalation from the onset of specified vital sign abnormalities to arrival in the MICU of greater than 12 h are associated with a significant increase in in-hospital mortality. These findings occur despite the evolution in the process of care for inpatient clinical deterioration, including early warning systems and rapid response teams, which do not appear sufficient to fully mitigate the harm associated with delays. If hospitals and health systems are to address the frequency and potential harms of such delays, investigation into sources of delay will be necessary. Development of performance measures for the care of clinically deteriorating inpatients remains essential and deserves further consideration.

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Corresponding Author: *Christopher B. Sankey, MD; Section of General Medicine, Department of Internal MedicineYale University School of Medicine, Harkness Hall A, Room 306, 367 Cedar St., New Haven, CT 06510, USA (e-mail: christopher.sankey@yale.edu).*

Compliance with Ethical Standards:

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