Published in final edited form as:

J Radiol Nurs. 2015 March 1; 34(1): 29–34. doi:10.1016/j.jradnu.2014.11.003.

Patients in the radiology department may be at increased risk of developing critical instability

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Abstract

The purpose of this study was to calculate the event rate for in-patients in the Radiology Department (RD) developing instability leading to calls for Medical Emergency Team assistance (MET-RD) compared to general ward (MET-W) patients. A retrospective comparison was done of MET-RD and MET-W calls in 2009 in a U.S. tertiary hospital with a well-established MET system. MET-RD and MET-W event rates represented as MET calls/hour/1000 admissions, adjusted for length of stay (LOS); rates also calculated for RD modalities. There were 31,320 hospital ward admissions had 1,230 MET-W, and among 149,569 radiology admissions there were 56 MET-RD. When adjusted for LOS, the MET-RD event rate was 2 times higher than the MET-W rate (0.48 vs. 0.24 events/hour/1000 admissions). Event rates differed by procedure: computed tomography (CT) had 38% of MET-RDs (event rate 0.89); magnetic resonance imaging (MRI) accounted for 27% (event rate 1.56). Nuclear medicine had 1% of RD admissions but these patients accounted for 5% of MET-RD (event rate 1.53). Interventional radiology (IR) had 6% of RD admissions but 16% of MET-RD (event rate 0.61). While general x-ray comprised 63% of RD admissions, only 11% of MET-RD involved their care (event rate 0.09). In conclusion, the overall MET-RD event rate was twice the MET-W event rate; CT, MRI and IR rates were 3.7–6.5 times higher than on wards. RD patients are at increased risk for a MET call compared to ward patients when the time at risk is considered. Increased surveillance of RD patients is warranted.

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The authors declare no conflicts of interest

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Introduction

Rapid Response Systems (RRS) are designed to provide a system-level response for patients who become unstable in an area of the hospital where resources do not match patient needs (DeVita et al., 2006). RRS commonly utilize a medical emergency team (MET) consisting of physicians, nurses and other critical care providers to respond to calls from throughout the institution to assist in stabilizing critically unstable patients. MET calls can be initiated by anyone in any area of the hospital, including the Radiology Department (RD).

During hospitalization, many patients require tests or interventions that involve off-unit transport to undergo a radiologic procedure or diagnostic test (Warren, Fromm, Orr, Rotello, Horst, & American College of Critical Care Medicine, 2004; Voigt, Pastores, Raoof, Thaler, & Halpern, 2009; Szem, Hydo, Fischer, Kapur, Klemperer, & Barie, 1995). Prior studies indicate that one-fourth to one-half of all intensive care unit (ICU) patients require transport outside the ICU at least once during their hospitalization (Voigt et al., 2009). However, far fewer studies have investigated risks when non-ICU patients require transport. In one state-wide study (Pennsylvania), 208 near-miss or serious events, over a 4 years period, were reported while patients were away from the general wards for RD procedures (Pennsylvania Patient Safety Authority, 2009). Our earlier project examining RD events identified several risk factors for MET calls in the RD, including transport from a non-critical care units, a greater number of comorbidities, and recent vital sign changes (Ott, Pinsky, Hoffman, Clarke, Clark, Ren, & Hravnak, 2012).

To further define risk for a MET compared to general wards, we proposed to compare event rates in the RD (MET-RD) to those occurring in general wards (MET-W), as well as determine the event rates for specific modalities in the RD. Because patients are in the RD for relatively short time periods, a comparisons of event rates for RDs versus wards must take time at risk, i.e. time in the care area or dose of care, into consideration.

Methods

Sample and Setting

The project was conducted in a tertiary academic medical center with a well-established MET. At the time of the project, MET criteria had been established and posted on all clinical units as well as the RD (Table 1). The project was approved by the hospital Patient Safety Committee in conjunction with the University of Pittsburgh Medical Center Internal Review Board.

Variables

The following data were obtained from hospital databases for 2009: 1) number of hospital admissions; 2) number of MET-RD and MET-W calls; 3) hospital length of stay (LOS); 4) number of RD visits by RD specialty modality [i.e. magnetic resonance imaging (MRI), computed tomography (CT), interventional radiology (IR), nuclear medicine (NM), general x-ray including fluoroscopy (XR), and ultrasound (US)], and 5) patient transport data. Since radiology LOS (LOS-RD) was not discretely recorded, we calculated LOS-RD using patient transport data and defined it as time elapsed (hours) from when the patient left the ward for

the RD until ward return. For patients who experienced a MET-RD, LOS-RD was calculated as time elapsed from when the patient left the ward until the MET-RD was called. Since patient transport data were not available for February 2009, the entire analysis was conducted on 11 months of data, excluding February.

Statistical Analysis

All data management and statistical analyses were done using SAS[®] 9.2 and SPSS[®] 19. Event rates of MET-RD were calculated as the number of MET-RD calls/LOS-RD in hours/1000 RD visits. Similarly, event rates for MET-W were calculated as MET-W calls/hospital LOS in hours/1000 hospital admissions. Each patient encounter in the RD was considered a separate RD visit or RD admission. Results are presented as frequencies with proportions and means with standard deviations (SD).

Results

There were 31,320 hospital admissions with an average LOS-hospital of 160.8 hours (6.7 days), and 1230 MET-W calls. There were 149,569 RD visits by inpatients from wards with an average LOS-RD of 0.78 hours (46 minutes), and 56 MET-RD calls. RD visits per month remained constant throughout the year with a slight increase in July and appeared to be unaffected by fluctuations in hospital admissions (Table 2). MET-RD and MET-W differed in pattern of occurrence (Table 2). While MET-W calls per month remained fairly consistent throughout the year, MET-RD calls increased in April and May and decreased in July, August and November. The event rate for MET-RD was 0.48 events/RD LOS hour/1000 RD visits compared to an event rate of 0.24 events/hospital LOS hours/1000 hospital admission for MET-W (Figure 1).

All the RD modalities had MET-RD event rates higher than the average MET-W event rates (Figure 1, Table 3). When examining MET-RD prevalence by RD modality (Table 3), the majority of MET-RDs occurred in the CT suite (38% of MET-RD, average CT LOS 0.83 hours; event rate 0.89). MRIs represented only 5% of RD visits, but accounted for 27% of MET-RD calls. The average LOS in MRI (1.38 hours) was 1.8 times longer than the average LOS-RD, yielding an MRI event rate of 1.56, which was the highest in the RD. The longest LOS-RD was seen in NM (1.62 hours). Although NM patients represented only 1% of RD visits and 5% of MET-RD calls, the event rate (1.53) was equal to that for MRI patients. The event rates for MRI, NM and CT were each 3.7–6.5 times greater than the MET-W event rate. The IR event rate was 2.5 times greater than the MET-W event rate, while event rates of XR (0.09) and US (0.19) were less than the MET-W rates.

MET-RD patients had a similar median LOS (0.78 hours) to those not experiencing this event (0.77 hours) suggesting that radiology LOS was not a risk factor for MET-RD (Figure 2a). However, patients who experienced a MET-RD during CT had a shorter median LOS-RD (0.37 hours) compared to those not experiencing an event (0.7 hours), suggesting that the MET-RD event occurred early in the visits for CT (Figure 2b).

MET-W events occurred most frequently during the daylight shift with the greatest number of events between 8:01 and 10:00 (n=143; Figure 3). MET-RD events occurred most frequently between 10:01 and 12:00 (n=15; Figure 3).

Almost half (46%) of the MET-RD calls occurred in the first 24 hours of the patients' hospitalization, and 61% of the patients had a Charlson Co-morbidity Index ≥ 5 . The majority of patients (64%) arrived to the RD on supplemental oxygen prior to the MET-RD call. Additionally, one third of the patients had documented tachypnea (respiratory rate >24 breaths per minute), tachycardia (heart rate > 100 beats per minute) and cardiac arrhythmias documented in the electronic health record by a nurse during the 12 hours prior to the MET-RD call. The most common reason for a MET-RD call was for a respiratory etiology (29%) with the majority of these calls in CT. The second most common reason for a MET-RD call was for seizure (16%) with the majority of these calls in MRI.

Discussion

To our knowledge, our project is the first to analyze instability in inpatients coming to the RD manifested by the need for MET activation in relation to events in the general ward adjusted for total time of care in each location of the hospital. Notably, our findings suggest that RD patients are at greater risk for acute decompensation as indicated by need for a MET call, compared to their stay on the ward, when the length of time that the patient is in the care area is taken into account. Our finding also suggest that MET-RD event rates vary widely among RD modalities, with the highest rates of MET-RD occurring for patients requiring CT, MRI or NM tests. For CT, these events appear to occur early after arrival in the RD.

As anticipated, total MET calls to the hospital wards were higher than the number of MET calls to the RD. However, when adjusted for LOS, our data demonstrated a MET-RD event rate twice that of the MET-W event rate. Thus, patients appear to be at significantly greater risk for a MET event while in the RD as compared to their usual care area when time in the area is considered. Potentially, patients who require transport to the RD may represent a subset of patients at greater risk for instability (Szem et al. 1995, Hurst et al. 1992).

In our prior work (Ott et al. 2012), we reported that MET-RD calls were primarily due to cardiac instability (55%), followed by respiratory (21%) and neurologic (21%) manifestations. MET-RD patients frequently arrived in the RD on oxygen (86%), cardiovascular support (48%) and had documented prior cardiac arrhythmias (41%). Further alterations in vital signs were documented for the majority in the 12 hours prior to the MET-RD, with 27% showing vital sign instability meeting or exceeding the local MET call criteria (Table 1) before coming to the RD. Such instability may in fact be the trigger for the procedure leading to the RD visit in the first place (Szem et al., 1995, Hurst, Davis, Johnson, Branson, Campbell, & Branson, 1992) and RD inpatients may represent a generally sicker pool of patients.

Prior literature reported that, MET-W events occurred more frequently at the change of shift when new clinicians are evaluating patient condition (Hravnak, Edwards, Clontz, Valenta,

DeVita, M., & Pinsky, 2008). The MET-W events of our analysis also found an increase at the start of the daylight shift. However, MET-RD events increased in frequency later during the daytime shift and then again during the evening shift, suggests that the MET-RD events were influenced by different circumstances.

RD providers face a number of challenges when attempting to maintain patient surveillance, including the need for protective barriers, placement required for procedures, and limited monitor visibility. In addition, RD clinicians are managing the care of a patient unfamiliar to them (Ott et al., 2009). Factors that precipitate the need for transport to the RD are likely another important influence. Patients receiving RD studies were likely in a more acute phase of their illness as almost half of MET-RD calls occurred in the first 24 hours after hospital admission. The propensity for RD patients to become unstable may also be compounded by RD specific factors such as the need for sedation and potential for vascular catheters and endotracheal tubes to become dislodged during transfer to scanning tables.

In addition to differences between the MET-W and the overall MET-RD event rate, we also found differences in MET-RD event rates across the radiologic modalities. Our CT LOS (0.83 ± 0.48 hours) was slightly lower than reported in the literature (Stevenson, Hass, & Wahl, 2002). CT had the highest MET-RD call volume, comprising 38% of all MET-RD, and a CT MET-RD event rate of 0.89 events/hour/1000 RD visits. In general, CT scanning time averages 1.03–1.53 hours (Stevenson et al., 2002) which is much shorter than the average time required to complete a MRI or angiography. Hence, CT may be erroneously viewed as a “safer” diagnostic procedure for unstable patients. We speculate that patients undergoing CT scanning may receive a lower level of surveillance than those in other more complex procedures due to the presumption that shorter scanning time equates to lower risk. Our project confirmed CT as a high volume procedure with 19% of all RD exams, second only to general radiology. Interestingly, patients who experienced a MET-RD during CT had a shorter LOS in the RD than those not experiencing a MET, which suggests that when instability occurs, it manifests early in the procedure. The higher rates of MET calls for CT patients might reflect higher patient acuity and less surveillance (quantity, quality or both), contributing to a greater likelihood to destabilize. Since patients rarely progress to marked instability instantly, (Hravnak et al., 2008) a sense of false security during CT procedures could at least partially explain the higher event rate in this RD specialty.

We found that the MET-RD event rates were highest for MRI (1.56 events/hour/1000 RD visits). Although MRI represented only 5% of the RD volume, 27% of the MET-RD calls originated during a MRI. Since MRI LOS was 1.7 times greater than CT LOS, and direct observation of patients during MRI is limited, patients undergoing this type of imaging represent a group for whom focused monitoring might also be of greatest benefit in improving patient safety.

The longest procedures were not necessarily associated with higher rates of MET-RD. LOS was longest in NM and IR. NM represented the lowest volume of patients and 5% of the MET-RD calls. The institutional staffing standard in IR consists of a 1:1 patient: nurse ratio in addition to an IR physician and IR technician. Thus, IR patients had the highest level of

continuous surveillance which may explain their lower MET-RD event rate, despite the second longest average LOS.

More study is needed to determine if an increased level of patient surveillance (number or role of clinicians and their proximity to patients, ability of staff to read monitoring devices, as well as use of more sensitive and specific instability detection technology) in the various RD modalities would reduce MET-RD event rates, or if the different event rates reflect differing patient acuity and co-morbidities.

Limitations

The project was conducted in an academic medical center with a well-established MET system that may not be representative of other health care facilities. The retrospective methodology required collection of data from existing databases and, as a consequence, we were unable to quantify RD patient acuity or precisely determine time in the RD minus their transport time. From the moment the patient leaves the regular ward, their monitoring changes and patient transport time is usually short, relative to time in the RD. Hence, it appeared appropriate to include transport time in the RD-LOS calculation. Additionally, we were unable to locate one month of LOS-RD data, requiring elimination of this month (February) from the analysis. We were unable to identify differences in visit rates during February, suggesting that exclusion of these missing data did not alter our findings. A further limitation of this project was the data sources used to identify predictors of instability in RD patients. A prospective study is needed to validate the results of this retrospective project.

Conclusions

Hour for hour, patients hospitalized on wards were more likely to experience instability requiring a MET call while in the RD compared to while on a hospital ward. MET-RD rates were not evenly distributed across RD modalities. Patients appeared to be at greater risk for a MET-RD call while undergoing MRI, NM or CT, and at greater risk early in CT procedures. Our findings suggest circumstances when patients in the RD may be at greatest risk for a MET event, and, therefore in need of greater surveillance during procedures or diagnostic tests. Whether difference in MET event risk relates to pre-existing risk for instability (prior to transport) or decreased surveillance (transport monitors, staff number or mix, or staff to patient proximity and visibility) or both, requires further study. Our findings suggest that, at a minimum, the same level of monitoring and clinical care should be provided to patients in the RD as they receive on the clinical unit. Clinicians sending patients to the RD for MRI, NM, or CT should recognize that those patients are at increased risk for developing instability and establish a plan for patient surveillance and care to improve patient safety.

Acknowledgments

Funding: Lora Ott: 1F31NR012343 and the Leslie A. Hoffman Endowed Research Award

Michael R. Pinsky: 2K24 HL067181

Sunday Clark: UL1 RR024153 and UL1TR000005

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Highlights

- Hour for hour patients were more likely to experience instability requiring a MET call while in the RD compared to while on a hospital ward.
- The same level of monitoring and clinical care should be provided to patients in the RD as they receive on the clinical unit.
- Radiology should be considered a continuation of patient care not an interruption in patient care.
- Clinicians sending patients to the RD for MRI, NM or CT should recognize that those patients are at increased risk for developing instability.
- Radiology nurses should establish a plan for patient surveillance and care to improve patient safety.

Figure 1.

Event rates of Medical Emergency Team calls on the hospital ward (MET-W) and Medical Emergency Team calls in the Radiology Department (MET-RD) calls (left panel) and event rates by radiology separate modalities (right panel). (Event rates were calculated as # MET events in location/hours in location/visits in location)

* Events/hour/1000 RD modality visits

Figure 2. a: Graphic representation of Radiology Department (RD) and Medical Emergency Team calls in the Radiology Department (MET-RD) patient length of stay

	All RD N=19,410 LOS (hrs)	MET-RD N=56 LOS (hrs)
Mean (SD)	0.96 (0.65)	0.69(0.33)
Median	0.77	0.78
Minimum	0.1	0.12
Maximum	6.17	1.53

b: Graphic representation of Computed Tomography (CT) and Medical Emergency Team calls in the Radiology Department that occurred in Computed Tomography (CT MET-RD) patient length of stay.

	All CT N=4,696 LOS (hrs)	CT MET-RD N=21 LOS (hrs)
Mean (SD)	0.83 (0.48)	35.81 (22)

Median	0.7	0.37
Minimum	0.1	0.28
Maximum	5.92	1.53

Figure 3.

Comparison of calls by time of day for Medical Emergency Team calls in the Radiology Department (MET-RD) and Medical Emergency Team calls on the hospital ward (MET-W)*.

* February data was not available therefore analysis was conducted on 11 months.

Table 1

Study site Medical Emergency Team call criteria in 2009.

Respiratory Rate <8 or >36 New onset of difficult breathing New pulse oximeter reading <85% for >5 min without known chronic hypoxia New oxygen requirement to keep SpO ₂ >85% Bleeding into airway	Cardiovascular Heart Rate <40 or >140 with new symptoms or any rate >160 Blood pressure <80 or >200 systolic or 110 diastolic with symptoms (neurologic changes, angina, dyspnea) Uncontrolled bleeding Large acute blood loss Patient complaint of chest pain (unresponsive to nitroglycerine or MD unavailable)	Acute Neurologic Change Acute loss of consciousness New onset lethargy Sudden collapse Seizure (outside of seizure monitor unit) Sudden loss of movement or weakness in the face, arm or leg
Other >1 STAT page required to assemble team needed to respond to a crisis; Color change (patient or extremity): Pale, dusky, gray or blue; Unexplained agitation of >10 min.; Narcan use without immediate response; Suicide attempt; Crash cart must be used for rapid delivery of meds		

Table 2
Radiology visits, Medical Emergency Team in the Radiology Department (MET-RD),
Hospital Admissions and Medical Emergency Team in the Hospital Wards (MET-W) per
month in 2009^I

2009^I	Radiology Visits n=149,569 (%)	MET-RD n=56 (%)	Hospital Admissions n=31,320 (%)	MET-W n=1230 (%)
January	13528 (9%)	6 (11%)	2955 (10%)	167 (11%)
March	13969 (9%)	5 (9%)	3010 (10%)	160 (10%)
April	14020 (9%)	7 (13%)	2930 (10%)	156 (10%)
May	13866 (9%)	8 (14%)	2862 (9%)	118 (8%)
June	12968 (9%)	5 (9%)	2788 (9%)	100 (6%)
July	14710 (10%)	2 (4%)	2959 (10%)	144 (9%)
August	13844 (9%)	3 (5%)	2814 (9%)	110 (7%)
September	12632 (8%)	6 (11%)	2810 (9%)	116 (7%)
October	13321 (9%)	6 (11%)	2878 (9%)	161 (10%)
November	13025 (9%)	3 (5%)	2614 (8%)	159 (10%)
December	13696 (9%)	5 (9%)	2191 (7%)	164 (11%)

^I February data was not available therefore analysis was conducted on 11 months.

Table 3

Total Radiology (RD) visits, Radiology visits per modality, Medical Emergency Team in the Radiology Department (MET-RD) event rate, radiology length of stay and event rate per radiology modality.

	RD visits 2009 n=149,569	Radiology Study Subjects by Modality ¹ n=19,410	MET-RD Events 2009 n=56	Radiology Length of Stay (hrs) (±SD)	Event rate ²
RD Modality n (%)					
Magnetic Resonance Imaging	6,962 (5%)	1,966 (10%)	15 (27%)	1.38 (0.61)	1.56
Nuclear Medicine	1,211 (1%)	341 (2%)	3 (5%)	1.62 (0.95)	1.53
Computed Tomography	28,453 (19%)	4,696 (24%)	21 (38%)	0.83(0.48)	0.89
Interventional Radiology	9,409 (6%)	2,133 (11%)	9 (16%)	1.57 (0.8)	0.61
General X-Ray	93,606 (63%)	7,873 (41%)	6 (11%)	0.7 (0.52)	0.09
Ultrasound	9,928 (6%)	2,401 (12%)	2 (4%)	1.07 (0.5)	0.19

¹ Patient totals of those patients with complete intrahospital transport data used to calculate length of stay in Radiology

² Events/hour/1000 RD modality visits