# Optimizing Cardiac Monitoring Utilization in the Emergency Department for Patients Awaiting In-Hospital Beds

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## ABSTRACT

**Purpose:** Emergency department (ED) crowding is a growing crisis and beds with cardiac monitors are a very limited resource. This study aims to assess the use of cardiac monitoring among patients waiting in the ED for an inpatient bed, interventions due to monitoring, and identify risk factors for serious adverse events (SAE) to optimize the use of monitors.

**Methods:** We performed a 2-week health records review of hospitalized/boarded patients in the ED on cardiac monitors. We collected baseline characteristics and outcomes including serious adverse events (SAE; e.g., arrhythmia, hypotension) during the ED stay. We used descriptive statistics and a logistic regression analysis of six pre-determined variables to identify risk factors for SAE requiring intervention: age, past medical illness [chronic: hypertension, diabetes, cancer, chronic obstructive pulmonary disease, heart failure; or severe: pacemaker, previous Intensive Care Unit (ICU) stay, previous cardiac arrest, coronary artery disease, arrhythmia], abnormal vital signs (HR <50 or >105bpm, RR <8 or >25, $SpO_2$ <90% or supplemental $O_2$, mean arterial pressure <60 or >160mmHg, T<35 or >38°C), admission diagnosis, admission destination (monitored or unmonitored location), and Canadian Triage and Acuity Scale (CTAS) score.

**Results:** 305 patients (mean age 63.7 years; 52.5% male and 47.5% female) of whom 56 (18.4%, 9 with arrhythmia) suffered SAE. Patients admitted under Internal Medicine and Cardiology utilized the most hours on cardiac monitors (1,716.0 and 917.6 hours, respectively) and had the highest numbers of patients with SAE requiring intervention (33 patients total). Patients under Neurology and Medical Oncology had the highest SAE rate (38.5% and 35.7%, respectively). Variables associated with SAE requiring intervention were chronic (OR 4.89, p=0.04) or severe (OR 4.04, p=0.04) illness, abnormal vital signs (OR 3.55, p=0.002) and monitored destination (OR 2.32, p=0.03). These risk factors were associated with SAE during ED stay with 100% (93.2-100%) sensitivity and 4.7% (2.5-8.1%) specificity.

**Conclusion:** Our study revealed risk factors for identification of a SAE requiring intervention among hospitalized patients who undergo cardiac monitoring during their ED stay. Patients with no chronic or severe illness, normal vital signs and destined to an unmonitored inpatient location can potentially be removed from cardiac monitoring in the ED. Prospective studies are needed to develop a safe clinical decision tool for identification of hospitalized patients requiring ED cardiac monitoring while awaiting inpatient bed.

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## RÉSUMÉ

**Objectif :** La surcharge des services d'urgence constitue une crise croissante et les lits équipés de moniteurs cardiaques sont une ressource très limitée. Cette étude vise à évaluer l'utilisation de la surveillance cardiaque chez les patients en attente d'un lit d'hospitalisation aux urgences, à décrire les interventions induites par cette surveillance et à identifier les facteurs de risque d'événements indésirables graves afin d'optimiser l'emploi des moniteurs.

**Méthodes :** Nous avons réalisé sur une période de deux semaines une revue des dossiers médicaux des patients hospitalisés ou en observation dans le service des urgences sous surveillance cardiaque. Nous avons recueilli les caractéristiques de base et les résultats, y compris les événements indésirables graves (p. ex., arythmie, hypotension) durant le séjour aux urgences. Nous avons appliqué des statistiques descriptives et une analyse de régression logistique portant sur six variables prédéterminées pour identifier les facteurs de risque d'événement indésirable grave nécessitant une intervention : l'âge, les antécédents médicaux [chroniques : hypertension, diabète, cancer, maladie pulmonaire obstructive chronique, insuffisance cardiaque ; ou sévères : stimulateur cardiaque, séjour antérieur en unité de soins intensifs (ICU), antécédent d'arrêt cardiaque, coronaropathie, arythmie], les signes vitaux anormaux (FC < 50 ou > 105 bpm, FR < 8 ou > 25, $SpO_2$ < 90 % ou recours à l'oxygène, pression artérielle moyenne < 60 ou > 160 mmHg, T < 35 ou > 38 °C), le diagnostic à l'admission, le lieu d'hospitalisation (secteur avec ou sans surveillance) et le score CTAS (échelle canadienne de triage et d'acuité).

**Résultats :** 305 patients (âge moyen 63,7 ans ; 52,5 % d'hommes et 47,5 % de femmes), dont 56 (18,4 %, dont 9 avec arythmie) ont présenté un événement indésirable grave. Les patients admis en médecine interne et en cardiologie ont cumulé le plus d'heures de surveillance cardiaque (1 716,0 et 917,6 heures, respectivement) et comptaient le plus grand nombre de patients ayant eu un événement indésirable grave nécessitant une intervention (33 patients au total). Les patients en neurologie et en oncologie médicale affichaient les taux d'événements indésirables graves les plus élevés (38,5 % et 35,7 %, respectivement). Les variables associées à un événement indésirable grave nécessitant une intervention étaient : maladie chronique (rapport de cotes 4,89, p = 0,04) ou grave (rapport de cotes 4,04, p = 0,04), signes vitaux anormaux (rapport de cotes 3,55, p = 0,002) et lieu d'hospitalisation surveillé (rapport de cotes 2,32, p = 0,03). Ces facteurs de risque étaient associés aux événements indésirables graves durant le séjour aux urgences avec une sensibilité de 100 % (93,2–100 %) et une spécificité de 4,7 % (2,5–8,1 %).

**Conclusion :** Notre étude a mis en évidence les facteurs de risque permettant d'identifier un événement indésirable grave nécessitant une intervention chez des patients hospitalisés bénéficiant d'une surveillance cardiaque pendant leur séjour au service des urgences. Les patients sans maladie chronique ni pathologie grave, présentant des signes vitaux normaux et dirigés vers un service d'hospitalisation sans surveillance continue pourraient potentiellement être retirés de la surveillance cardiaque aux urgences. Des études prospectives sont nécessaires pour développer un outil décisionnel clinique sûr destiné à identifier les patients hospitalisés qui nécessitent une surveillance cardiaque aux urgences en attendant l'attribution d'un lit.

## INTRODUCTION

Emergency department (ED) beds with continuous cardiac monitoring are costly and a limited resource. Ideally, these beds should be reserved for critically ill patients who are at high risk for cardiac dysrhythmias and hemodynamic instability. Previous literature examining patients admitted to hospital has demonstrated that routine telemetry offers very little cardiac arrest survival benefit in most cases[1]. Unnecessary prolonged monitoring may even lead to undesired consequences. For example, routine continuous electrocardiographic monitoring in the ED for patients with low-risk chest pain have been shown to result in a high rate of alarms (4.7 alarms per monitored hour) with only a small minority (0.2%) of them triggering a change in management[2]. Even though patients with elevated troponins without ST-elevation myocardial infarction had fairly high rates of detected arrhythmias (26%), changes in management were uncommon (6.3%)[3].

ED crowding remains a growing problem universally. In addition to patients being assessed by emergency physicians, there are significant numbers of admitted patients remaining in ED beds, also known as boarded patients, due to inpatient bed overcapacity. As regional referral centers, many tertiary and quaternary care centers physically intake outside referrals though the ED to be seen by a specialty service, adding to the demands of cardiac monitoring space in the ED.

Practice standards for the use of cardiac monitoring in the hospital setting were first published in 1991 by the American College of Cardiology[4]. These were later revised in 2005 by the American Heart Association and again most recently updated in 2017 and 2021[5,6]. These guidelines, however, are not geared towards ED patients. There are no studies to date that examined the issue of ED cardiac monitoring of hospitalized patients. Wide variations in ED cardiac monitoring exist, resulting in long ED wait times, ambulance offload delays, and delay in acute care of high-risk patients waiting for a bed with cardiac monitoring.

By examining current practices amongst the different admitting services and analyzing clinical outcomes related to admitted patients on continuous cardiac monitoring in the ED, we can reduce unnecessary utilization of monitored beds in the ED and shift those resources more appropriately to critically ill patients.

The primary objectives of this study were to assess the proportion of patients who received clinical interventions in response to close cardiac monitoring and the length of time spent on monitors by boarded patients in the ED. The secondary objectives were to assess the proportion of patients with events that did not lead to changes in patient management and to identify factors associated with safe discontinuation of cardiac monitoring to optimize ED use of cardiac monitors for boarded patients.

## METHODS

### Study Design and Setting

This study was a health records review conducted over a 2-week period (December 1st to 14th, 2015) at the two academic tertiary care EDs of The Ottawa Hospital. This regional trauma center is also the referral destination for many subspecialties such as cardiac, vascular, and neurosurgical emergencies. This 1,163-bed facility annually handles over 160,000 emergency visits, nearly 1 million ambulatory care visits, and roughly 70,000 surgical cases[7]. The ED is staffed by 95 staff physicians, approximately 250 registered nurses, and around 60 emergency medicine residents. Data collection was performed by a member of our research team, where each chart was reviewed manually. Patients' medical record numbers were linked to unique study identification number which were kept on a hospital secure server. Research ethics board approval was received to conduct this study (OHSN REB protocol # - 20160543-01H).

### Population

The patient population included all who were admitted to hospital from the ED and spent any amount of time in a monitored bed while boarded in the ED. Patients that did not spend any time in a cardiac monitored bed during their ED stay were not eligible. Patients were excluded if they had return of spontaneous circulation (ROSC) after a cardiac arrest, a diagnosis of ST-elevation myocardial infarction (STEMI), significant trauma that resulted in a code trauma called upon arrival to the ED, presented with symptoms consistent with a stroke leading to a code stroke activated upon their arrival, or if they were intubated prior to admission. These patients were excluded as it was felt that did not present a clinical dilemma regarding appropriate use of cardiac monitoring.

### Data Collection

We collected patient demographics, baseline characteristics and clinical data obtained during the ED visit. We collected past medical history including dysrhythmia as part of baseline characteristics. Dysrhythmias were defined as any abnormal variation from normal sinus rhythm, such as irregularities and disturbances to rate and/or conduction. ED clinical data included the patients' presenting complaint, admission diagnosis, admission destination, admission vitals and time metrics (length of stay on monitor and in the in the ED) and the Canadian Triage and Acuity Scale (CTAS) score. The CTAS is a tool used in EDs to prioritize patient care by triaging patients according to acuity based on their presenting signs and symptoms. The CTAS has five levels: level 1- resuscitation (i.e., cardiac arrest), level 2 – emergent (i.e., chest pain with cardiac features), level 3 – urgent (i.e., vomiting and/or nausea with mild dehydration), level 4 – less urgent (i.e,, chronic confusion), level 5 – non-urgent (i.e., medication request).

### Outcome Measures

The study outcome measures were arrhythmias detected on monitor, interventions performed due to cardiac monitoring and mortality during the ED and hospital stay.

### Statistical Analysis

We used descriptive statistics and reported mean with standard deviation for continuous variables, and frequencies with percentages for categorical variables. We used multivariable logistic regression to identify variables associated with intervention in response to events identified through ED cardiac monitoring. Based on clinical sensibility and input from emergency medicine researchers and quality improvement experts, we chose six variables a priori for model development. The variables included age, past medical history, vital signs, admission diagnosis, admission destination and CTAS score. With the intent of identifying those at risk for arrhythmias we classified past medical history into either chronic or severe illness. Chronic illnesses included hypertension, diabetes mellitus, cancer, and chronic obstructive pulmonary disease. Illnesses considered severe involved a history of pacemaker insertion, Intensive Care Unit (ICU) stay, cardiac arrest, coronary artery disease, arrhythmias, or heart failure. Based on consensus and previous publications, we classified the vital signs as abnormal if the temperature was <35 or >38°C, heart rate was <50 or >105bpm, respiratory rate was <8 or >25 respirations per minute, oxygen saturations were <90% or if the patient required supplemental oxygen due to hypoxia, or if the mean arterial pressure (MAP) was <60 or >160mmHg[8]. This MAP range was determined based on the known range for maintenance of cerebral autoregulation.

Our preliminary analysis after review of 94 patients showed that 19% of patients received an intervention for abnormalities identified during ED cardiac monitoring. To perform a multivariable logistic regression analysis with six variables, we would require at least 60 patients with events identified on cardiac monitor, considering 10 events per variable as recommended for prediction tool development[9]. Hence, we estimated that a sample size of approximately 300 patients will be needed for this study. We used Statistical Analysis System (SAS) (version 9.4) for data analysis and defined $p<0.05$ as statistically significant.

## RESULTS

### Participants

A total of 400 charts of patients who had spent any time in an area of the ED with available cardiac monitors were reviewed to assess for eligibility (Figure 1). Overall, 52 patients were found to be ineligible as they did not meet the study inclusion criteria: 50 of these patients had not spent any time on a cardiac monitor and 2 patients were never admitted. The remaining 348 patients were assessed for any exclusion criteria. Of these, 43 were excluded because of a stroke or trauma code being called upon their arrival to the ED, presenting to the ED in cardiac arrest, or being intubated prior to their admission. Finally, 305 patients were included in the study.

### Patient Characteristics

Baseline characteristics are detailed in Table 1. The mean age was 63.7 years old with males representing 52.5% (160 patients) and females representing 47.5% (145) of the patient population. In terms of past medical history, 40.0% of patients had at least one condition considered to be a severe illness, most commonly coronary artery disease (23.0%) and dysrhythmia (21.3%). 112 (36.7%) patients had a history of a chronic illness, most commonly hypertension (43.9%) and cancer (27.5%). 71 patients (23.3%) did not have a history of a severe or chronic illness. The majority of patients (66.9%) were triaged as CTAS 2 upon arrival to the ED. 160 (52.5%) patients were admitted to a

non-monitored area (inpatient ward) and 145 (47.5%) patients were admitted to a monitored area.

Cardiovascular emergencies such as acute coronary syndrome (69 patients, 22.6%), and sepsis/infections (52 patients, 17.0%) were the most common reasons for hospitalization. A small number of patients were diagnosed with an intra-abdominal emergency (15 patients, 4.9%) or a metabolic emergency, such as diabetic ketoacidosis, (16 patients, 5.2%).

More than half of patients were admitted either under Internal Medicine (104 patients, 34.1%) or Cardiology (62 patients, 20.3%) (Table 1). The mean duration per patient on cardiac monitor was highest for patients admitted under the following services: Radiation Oncology (mean 20.8 hours, 6 patients), Neurosurgery (mean 17.5 hours, 8 patients), Neurology (mean 16.9 hours, 13 patients), Internal Medicine (mean 16.5 hours, 104 patients) and Cardiology (mean 14.8 hours, 62 patients).

The total amount of cardiac monitoring hours utilized grouped by admitted service (Figure 2) reveals patients admitted under Internal Medicine utilized the most hours on a monitor, totaling to 1716.0 hours over the 2-week period. Patients admitted under Cardiology utilized the second most total hours on a monitor, with 917.6 hours. The remaining admitting services utilized markedly less monitored hours in total ranging from 219.7 hours by Neurology and 9.3 hours by Otolaryngology.

### Interventions and Arrhythmias

In total, there were 64 events (21.0%) detected from close patient monitoring. Arrhythmias were detected in 17 (5.6%) patients (Table 2), and an additional 47 (15.4%) patients underwent an intervention not related to an arrhythmia but resulting from close cardiac monitoring. The types of dysrhythmias detected are detailed in Table 2. Not all detected arrhythmias led to an intervention. Of the 17 detected arrhythmias, 9 required interventions: administering an anti-arrhythmic (5 patients, 1.6%), magnesium sulfate (1 patient, 0.3%), intravenous fluids (1 patient, 0.3%) or transfer to the resuscitation bay (2 patients, 0.7%). Ultimately, 8 of the 17 patients did not receive any intervention in response to their detected arrhythmia.

Some interventions were not due to a cardiac arrhythmia (Table 2). The interventions performed for the 47 patients

**Table 1. Patient Characteristics**

| Characteristics – n (%) | N=305 |
|---|---|
| **Age in Years**, Mean (Standard Deviation) | 63.7 (18.9) |
| Range | 17 – 96 |
| **Sex** | |
| Male | 160 (52.5) |
| Female | 145 (47.5) |
| **Past Medical History** | |
| Severe Illness | 122 (40.0) |
| Coronary Artery Disease | 70 (23.0) |
| Dysrhythmia | 65 (21.3) |
| Heart Failure | 44 (14.4) |
| Pacemaker | 10 (3.3) |
| Previous Intensive Care Unit Stay | 10 (3.3) |
| Previous Cardiac Arrest | 1 (0.3) |
| Chronic Illness | 112 (36.7) |
| Hypertension | 134 (43.9) |
| Cancer | 84 (27.5) |
| Diabetes | 77 (25.2) |
| Chronic Obstructive Pulmonary Disease | 54 (17.7) |
| None | 71 (23.3) |
| **Canadian Triage and Acuity Scale Score** | |
| 1 | 10 (3.3) |
| 2 | 204 (66.9) |
| 3 | 88 (28.9) |
| 4 | 3 (1.0) |
| 5 | 0 (0.0) |
| **Admission Destination** | |
| Ward | 160 (52.5) |
| Ward with Telemetry | 42 (13.8) |
| Acute Monitoring Area | 40 (13.1) |
| Operating Room | 14 (4.6) |
| Neuro Acute Care Unit | 14 (4.6) |
| Trauma Ward | 13 (4.3) |
| Coronary Care Unit | 12 (3.9) |
| Intensive Care Unit | 9 (3.0) |
| Cardiac Catherization Laboratory | 1 (0.3) |
| **Admission to Monitored Setting** | |
| Monitored Area | 145 (47.5) |
| Non-Monitored Area | 160 (52.5) |
| **Admission Diagnosis** | |
| Cardiovascular Emergencies | 69 (22.6) |
| Sepsis/Infections | 52 (17.0) |
| Fractures/Trauma | 25 (8.2) |
| Neurologic Emergencies | 21 (6.9) |
| Cancer and Complications | 18 (5.9) |
| Respiratory Emergencies | 17 (5.6) |
| Metabolic Emergencies | 16 (5.2) |
| Intra-Abdominal Emergencies | 15 (4.9) |
| Other | 72 (23.6) |
| **Admitting Service** | |
| Medicine | 104 (34.1) |
| Cardiology | 62 (20.3) |
| General Surgery | 17 (5.6) |
| Medical Oncology | 14 (4.6) |
| Neurology | 13 (4.3) |
| Trauma | 13 (4.3) |
| Others* | 82 (26.9) |

*Other admitting services include Orthopedic Surgery, Intensive Care Unit, Hematology, Nephrology, Neurosurgery, Gynecology, Radiation Oncology, Vascular Surgery, Thoracic Surgery, Family Medicine, Respirology, Urology, Gastroenterology, and Otolaryngology

because of monitoring who did not suffer an arrhythmia were: administration of an intravenous fluid bolus for hypotension (18 patients, 5.9%), supplemental oxygen for hypoxia (16 patients, 5.2%), anti-hypertensive therapy for hypertension (5 patients, 1.6%), or administration of vasopressor therapy for persistent hypotension (3 patients, 1.0%). The RACE (Rapid Assessment of Critical Events) team was consulted for 2 patients (0.7%) in response to persistent hypotension. The following types of intervention were each performed in one patient (0.3%) within the study cohort: vascular line placement for blood pressure monitoring due to hypotension, repeat ECG for ST elevations seen on monitor, or discontinuation of a medication for hypotension.

In-hospital mortality was assessed, both while admitted in the ED and after transfer out of the ED. None of the patients died in the ED and the mortality while in an inpatient ward was 6.2% (19 patients).

The rate of intervention varied according to admitting service (Figure 2). The highest interventions rates were found in Neurology (5 patients, 38.5% intervention rate), Medical Oncology (4 patients, 35.7% intervention rate), and Orthopedics (3 patients, 17.6% intervention rate). Internal Medicine and Cardiology had the highest absolute number of interventions in 22 (21.2%) and 11 (17.4%) patients, respectively.

### Logistic Regression Analysis

The multivariable logistic regression analysis of the six pre-determined variables (age, past medical history, abnormal vital signs, admission diagnosis, admission destination and CTAS) is detailed in Table 3. Three of the six variables were found to be statistically significant ($p<0.05$), indicating an association for requiring an intervention due to cardiac monitoring. The highest Odds Ratios (OR) were obtained for patients' past medical histories. Patients with histories of chronic or severe illnesses had ORs of 4.9 (95% CI 1.5, 16.3) and 4.0 (95% CI 1.2, 14.0), respectively ($p=0.04$). Patients with abnormal vitals had an OR of 3.6 (95% CI 1.6, 7.8; $p=0.002$). Finally, admitted patients assigned to a monitored setting had an OR of 2.3 (95% CI 1.1, 4.9; $p= 0.03$). Combined, the three statistically significant variables (past medical history, abnormal vitals and admission destination) provided a sensitivity of 100% (95% CI 93.2%, 100%) and specificity of 4.7% (95% CI 2.5%, 8.1%) for patients requiring an intervention due to cardiac monitoring as well as a 100% sensitivity for mortality in hospital.

## DISCUSSION

In our study, the highest intervention rates were seen in patients admitted under Neurology and Medical Oncology. The Medical Oncology service utilized less hours per patient on ED cardiac monitors. Internal Medicine and Cardiology services utilized the most total monitored hours in the ED and had moderately high intervention rates. When considering the high total monitored hours utilized by Internal Medicine and Cardiology and their moderately elevated intervention rates, given the large volume of patients admitted to these two services, further research to identify risk factors for interventions identified by monitoring in this population is needed.

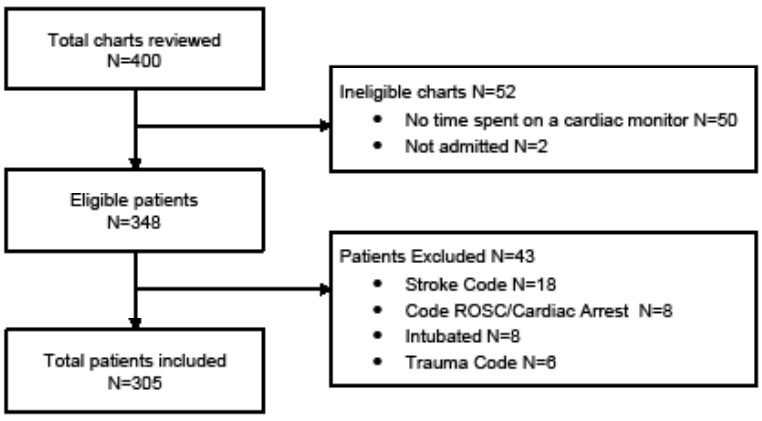
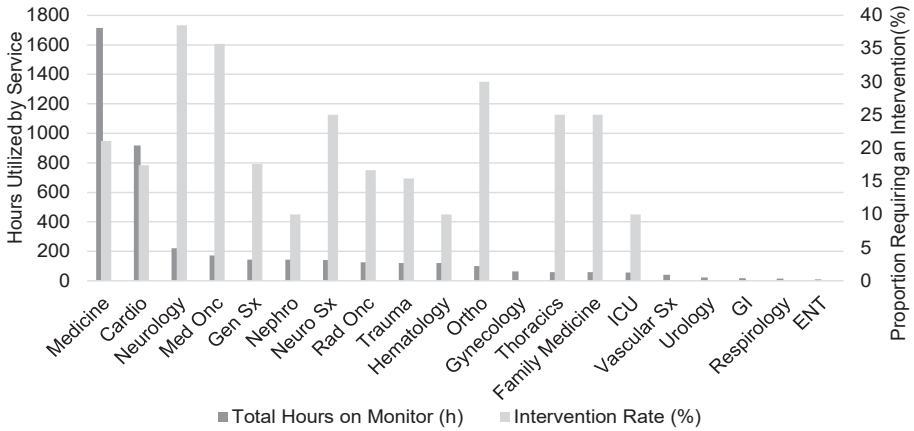



**Figure 1. Patient flowchart. Flow of participants through the study.**




Cardio (Cardiology), Med Onc (Medical Oncology), Gen Sx (General Surgery), Nephro (Nephrology), Neuro Sx (Neurosurgery), Rad Onc (Radiation Oncology), Ortho (Orthopedic Surgery), ICU (Intensive Care Unit), Vascular Sx (Vascular Surgery), GI (Gastroenterology), ENT (Otolaryngology)

**Figure 2. Total Hours on Cardiac Monitor vs Intervention Rate According to Admitting Service**

In keeping with previous literature, this study showed that overall, there was a very low incidence of interventions performed in response to detected arrhythmias from cardiac monitoring. Previous studies have reported high alarm rates for detected arrhythmias from cardiac monitors (26%) with only a small minority (6.3%) leading to a change in patient management[2]- our study observed similar results. The rate of arrhythmia detection was 5.6%, however only just over half of these patients (3.0% overall) underwent a subsequent intervention in response.

Overall, approximately 1 in 5 patients had events (i.e. arrhythmia, hypotension, hypoxia) detected due to close monitoring. There were notably far more interventions related to cardiac monitoring that were not due to an arrhythmia (i.e. fluid bolus for hypotension), in comparison to interventions solely due to an arrhythmia. The rates of these interventions were relatively high and suggests that closer clinical/nursing monitoring may be more important than actual cardiac monitoring. To our knowledge, there is no study specifically looking at this patient population and future studies identifying predictors for intervention may be warranted.

Previous studies have successfully created and prospectively validated clinical decision tools to aid ED physicians in safely identifying patients with chest pain that do not require further cardiac monitoring[10,11]. A similar decision tool predicting which boarded patients in the ED may require an intervention due to cardiac monitoring could not be developed based on our results. Half of the pre-determined variables (age, admission diagnosis, CTAS) did not show any statistically significant association with the need for an intervention. However, our multivariable logistic regression analysis yielded three variables that were significantly associated with requiring an intervention for patients boarded in the ED on cardiac monitors: chronic illness (hypertension, diabetes mellitus, cancer, chronic obstructive pulmonary disease or heart failure) or severe illness (pacemaker, previous ICU stay, previous cardiac arrest, coronary artery disease or history of arrhythmia), admission destination (monitored setting) and abnormal vital signs. Although these variables had fairly high ORs it should be noted that the associated confidence intervals were quite wide. They did however, when combined, have a sensitivity of 100% as predictors for intervention and were also 100% sensitive in predicting mortality.

This study is a retrospective chart review which should be noted as a limitation. Although there is paucity of research specifically on patients boarded in the ED on cardiac monitors, this study does stimulate additional research questions which ideally can be further investigated prospectively. Furthermore, this study investigated a relatively small sample size of patients. A large prospective study will allow identification of additional factors to construct a statistically robust clinical decision tool. Such a decision tool could be of particular value in patients admitted under services that utilize the most total hours on cardiac monitors in the ED, such as Internal Medicine and Cardiology.

**Table 2. Arrhythmias detected and interventions for patients on cardiac monitors**

| Variable – n (%) | N=305 |
|---|---|
| **Total Detected Arrhythmias** | **17 (5.6)** |
| Ventricular Tachycardia | 4 (1.3) |
| Sinus Bradycardia | 4 (1.3) |
| Atrioventricular Block | 2 (0.7) |
| Rapid Atrial Fibrillation | 2 (0.7) |
| Significant Sinus Tachycardia | 1 (0.3) |
| Significant Ectopy | 1 (0.3) |
| Junctional Bradycardia | 1 (0.3) |
| Junctional Tachycardia | 1 (0.3) |
| Supraventricular Tachycardia | 1 (0.3) |
| **Total Interventions Due to Detected Arrhythmias** | **9 (3.0)** |
| Anti-Arrhythmic | 5 (1.6) |
| Transferred to Resuscitation Bay | 2 (0.7) |
| Magnesium Sulfate | 1 (0.3) |
| Fluids | 1 (0.3) |
| No Intervention | 8 (2.6) |
| **Total Interventions Not Related to Detected Arrhythmias** | **47 (15.4)** |
| Bolus of Intravenous Fluids for Hypotension | 18 (5.9) |
| Supplemental Oxygen for Hypoxia | 16 (5.2) |
| Anti-Hypertensive for Hypertension | 5 (1.6) |
| Vasopressor for Hypotension | 3 (1.0) |
| Rapid Assessment of Clinical Events (RACE) Consult for Hypotension | 2 (0.7) |
| Line Placement for Blood Pressure Monitoring Due to Hypotension | 1 (0.3) |
| Repeat Electrocardiogram for ST Elevations on Monitor | 1 (0.3) |
| Home Medication Held for Hypotension | 1 (0.3) |

**Table 3. Logistic Regression Analysis for variables associated with a patient requiring an intervention**

| Variable | Odds ratio (95% CI) | p-value |
|---|---|---|
| **Age** | 1.01 (0.99; 1.03) | 0.39 |
| **Illness** | | 0.04 |
| Severe | 4.04 (1.16; 14.04) | |
| Chronic | 4.89 (1.47; 16.30) | |
| None | ref | |
| **Abnormal Vitals** | 3.55 (1.61; 7.81) | 0.002 |
| **Admission Diagnosis** | | 0.77 |
| Cardiovascular Emergencies | 0.93 (0.33; 2.63) | |
| Sepsis/Infections | 1.83 (0.65; 5.13) | |
| Fractures/Trauma | 2.54 (0.67; 9.64) | |
| Neurologic Emergencies | 2.38 (0.60; 9.50) | |
| Cancer and Complications | --* | |
| Respiratory Emergencies | 1.57 (0.38; 6.53) | |
| Metabolic Emergencies | 1.37 (0.23; 8.20) | |
| Intra-abdominal Emergencies | 2.58 (0.53; 12.90) | |
| Other | ref | |
| **Admission Destination** | | 0.03 |
| Monitored Area | 2.32 (1.11; 4,87) | |
| Non-Monitored Area | ref | |
| **CTAS** | | 0.49 |
| 1 | ref | |
| 2 | 1.51 (0.26; 8.68) | |
| 3 | 0.78 (0.12; 4.96) | |
| 4 | --* | |

*Odds ratio could not be calculated as no events were recorded that led to an intervention.
CI = Confidence Interval

## CONCLUSION

This study demonstrates that for patients boarded in the ED on cardiac monitors, approximately only one in five suffer an event detected due to close monitoring, and an even lower proportion require an intervention due to these detected events. Patients admitted to Internal Medicine and Cardiology utilize the most total hours on cardiac monitors with the highest absolute number of interventions due to cardiac monitoring. Results from this study showed that this patient population should specifically be further investigated. Additionally, three variables were identified as being associated with requiring an intervention due to cardiac monitoring with 100% sensitivity: past medical history (chronic or severe illness), admission to a monitored setting and abnormal vital signs. Based on these results, patients with no chronic or severe illness, normal vital signs and destined to an unmonitored inpatient location can potentially be removed from cardiac monitoring in the ED.

There is currently no validated tool to guide clinicians in identifying boarded patients in the ED that can be safely taken off a cardiac monitor. Further prospective studies will be needed to develop a robust tool to guide physicians in the optimal use of ED cardiac monitoring for boarded patients.

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**Conflicts of Interest Disclosure**
There are no conflicts of interest to declare.