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Needs Assessment: The need for this educational activity was determined by the American Board of Emergency Medicine, physician surveys, meetings with colleagues and board-certified physicians, previous participant evaluations, and attendance at annual conferences.

Goals: The goal of this activity is to adequately prepare physicians for the annual American Board of Emergency Medicine examination.

Learning Objectives: At the conclusion of this CME activity, you should be able to:

1. Assess a patient's need for admission to a telemetry bed.
2. Evaluate and manage adult patients with asymptomatic hypertension in the emergency department.
3. Practice noninvasive ventilation in acute cardiogenic pulmonary edema.
4. Assess time to treatment in primary percutaneous coronary intervention.
5. Distinguish if a patient with pericardial effusion has cardiac tamponade.
6. Assess critical issues in the evaluation and management of adult patients presenting to the emergency department with acute heart failure syndromes.
7. Assess drug-induced immune thrombocytopenia.
8. Describe oncologic emergencies: diagnosis and treatment.
9. Demonstrate abscess incision and drainage.
10. Determine if antibiotics are necessary after incision and drainage of a cutaneous abscess.
11. Recognize computed tomography as an increasing source of radiation exposure.
12. Describe emergency department procedural sedation with propofol.
13. Analyze missed and delayed diagnoses in the emergency department.
14. Demonstrate a better understanding of diagnostic failures.
15. Examine emergency physicians and disclosure of medical errors.
16. Examine refusal of care: the physician-patient relationship and decisionmaking capacity.
17. Be adequately prepared for the American Board of Emergency Medicine 2009 Lifelong Learning and Self-Assessment examination.

Target Audience: This activity is intended for board certified emergency medicine physicians.

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1. Read the printed material.
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4. CME certificates will be mailed to each participant scoring higher than 70%.

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To receive CME credit, complete the answer form on page 253.

REVIEW 1: WHEN DO PATIENTS NEED ADMISSION TO A TELEMETRY BED?

Article Citation: Chen E, Hollander JE. When do patients need admission to a telemetry bed? *J. Emerg Med.* 2007;33(1):53-60.

Reviewer: **Charles Stewart, MD, EMDM**, Director of Research, Department of Emergency Medicine, University of Oklahoma School of Medicine – Tulsa; Oklahoma Institute of Disaster and Emergency Medicine, Tulsa, OK

SYNOPSIS

The authors examined the evidence behind admitting patients to telemetry. Their contention is that telemetry monitoring is not indicated for patients who require transfusion alone, low risk patients with normal ECG, and stable patients undergoing treatment for pulmonary emboli. Monitoring is probably beneficial for patients with syncope, gastrointestinal hemorrhage, atrial tachyarrhythmias, and uncorrected electrolyte abnormalities. There is good evidence for monitoring patients who are admitted with a responding/firing implantable cardioverter-defibrillator, Mobitz type II block, complete heart block, decompensated congestive heart failure, acute cerebrovascular accident, acute coronary syndrome, and those requiring massive blood transfusion.

The authors feel that if the patient's admission diagnosis and treatment plan do not increase his or her risk above the general population, then the patient should not require telemetry monitoring simply because he or she is now in the hospital.

KEY POINTS

- There are only a limited number of telemetry monitored beds available in most hospitals.
- These beds are often used for patients who need intensive/frequent nursing care and monitoring such as a confused geriatric patient or for a patient requiring transfusion.
- When physicians do not systematically apply rigorous criteria for choosing inpatient telemetry admissions, these beds become unavailable for patients who would most benefit for them.
- The American Heart Association has established practice guidelines for ECG monitoring that include admission for chest pain, congestive heart failure, acute coronary syndrome, arrhythmia, syncope, acute cerebrovascular disease, and electrolyte disorders.
- Telemetry beds should be used when indicated and not simply because they are available.
- Stable pulmonary embolus patients can be safely monitored without cardiac monitoring.
- Stable COPD patients can be treated without cardiac monitoring.
- Patients receiving 1-2 units of blood for chronic anemia can be treated without cardiac monitoring.
- On the other hand, patients with massive transfusion will certainly require cardiac monitoring.
- Patients with an implanted defibrillator/pacemaker who experience complications will need a monitored bed.
- Patients with Mobitz type I or II or complete atrioventricular block will need a monitored bed.
- Patients with prolonged QT and associated ventricular arrhythmias require monitoring.

DISCUSSION

Introduction

The premise of the authors is that there are only a limited number of cardiac monitored beds available in a given facility. If these beds are used inappropriately, they become unavailable for patients who truly need them. When this happens, the emergency department becomes the holding area for these patients. As the dominoes fall, the emergency department becomes unable to care for new incoming patients. The authors believe that rigid adherence to guidelines (based on evidence, to be sure) will decrease this domino effect of bed unavailability.

Methods

The authors examined the evidence behind admitting patients with several common diagnoses to non-intensive care telemetry beds. They based their conclusions, in part, upon American Heart Association practice guidelines. The authors did note that the guidelines focus on cardiac conditions and added several non-

cardiac conditions where monitoring is useful. They performed a literature search for evidence that reinforced or refuted the need for a cardiac monitor for the top 10 admission diagnoses to telemetry and the 10 top diagnoses of hospital admissions through the ED.

Results

The study authors divided their list of conditions into three groups:

1. Those that certainly have good evidence for benefits from cardiac monitoring.
2. Those that have some evidence for benefits from cardiac monitoring.
3. Those that have scant evidence, no evidence, or conflicting evidence for cardiac monitoring.

The authors placed all of those patients who have cardiac conditions as described in the American Heart Association practice guidelines in the first group. These conditions include admission for chest pain, congestive heart failure, acute coronary syndrome, arrhythmia, syncope, acute cerebrovascular disease, and electrolyte disorders. The authors discussed the evidence that supports admission to a cardiac monitored unit for patients who have firing of an automatic defibrillator, those with a high degree atrioventricular block, those with prolonged QT and associated ventricular arrhythmias, those with acute heart failure or pulmonary edema, and those with massive blood transfusion.

In the second group, the authors noted that there is evidence for arrhythmia monitoring in patients who are admitted for syncope, those who have gastrointestinal bleeding after endoscopy, and those with atrial arrhythmias who are receiving therapy for rate or rhythm control. The authors discussed that patients with hyperkalemia, hypokalemia, hypomagnesemia, and hypocalcemia all have benefits from telemetry monitoring. Finally, they included those with mild congestive heart failure as showing some benefit from cardiac monitors.

In the final group of admissions, the authors noted that patients receiving 1-2 units of blood have little risk of a cardiac event and should not need monitoring. They pointed out that new protocols allow for outpatient treatment of mild pulmonary embolic disease without signs of instability.

Conclusions

The emergency physicians in this study identified several disease processes that they felt presented little or no risk for arrhythmia and did not require admission to a telemetry monitored bed. They cited patients with acute exacerbation of their COPD, patients with stable pulmonary embolism, patients who are admitted for a "rule-out" chest pain, and patients who are receiving blood and blood products for acute or chronic anemia.

CRITIQUE

I certainly agree with the authors' conclusion for patients with stable pulmonary embolism and those who are receiving blood for chronic anemia. I could be persuaded that the patient with acute exacerbation of COPD does not need cardiac monitoring. Unfortunately, I'm not sure that they drew the correct conclusion for at least one of these events: the 'rule-out" chest pain admission. They cited a prospective study of 467 patients admitted to a monitored unit where "only 5" arrhythmias were detected. They noted that there were 1.9% of the study patients who died, including 3 patients of this study who had ventricular fibrillation or cardiac arrest. Although their argument is academically correct, the wise and prudent physician in this age would probably not accept that nearly 1% of the admitted patients could die because they were not admitted to a monitored bed. Indeed, I fear that admitting the patient with chest pain to a non-monitored bed could be a medical/legal nightmare that would not survive public challenge in court. The authors failed to address this issue at all.

QUESTIONS

1.1 The authors used comprehensive guidelines for ECG monitoring from which specialty association for purposes of this study?

a. American Academy of Emergency Medicine.
b. Society for Academic Emergency Medicine.
c. American Academy of Cardiology.
d. American Heart Association.

1.2 Which of the following conditions are not covered by the comprehensive guidelines that the authors cite?

a. Chest pain.
b. Congestive heart failure.
c. Hemorrhage with an unstable pulse and blood pressure.
d. Electrolyte disorders.

Answers on page 230.

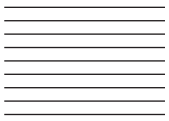
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Article 1
Journal of Emergency Medicine
Volume 33 Issue 1 – July 2007 – pages 53-60
Chen, et al
"When Do Patients Need Admission to a Telemetry Bed?"
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WHEN DO PATIENTS NEED ADMISSION TO A TELEMETRY BED?

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□ **Abstract—Non-intensive telemetry units are utilized for monitoring patients at risk for life-threatening dysrhythmias and sudden death. Physicians often use monitored beds for patients who might only require frequent nursing care. When 70% of the top 10 diseases admitted through the emergency department (ED) are clinically indicated for telemetry, hospitals with limited resources will be overwhelmed and admitted patients will be forced to wait in the ED. We examine the evidence behind admitting patients to telemetry. There is evidence for monitoring in patients admitted for implantable cardioverter-defibrillator firing, type II and complete atrio-ventricular block, prolonged QT interval with ventricular arrhythmia, decompensated heart failure, acute cerebrovascular event, acute coronary syndrome, and massive blood transfusion. Monitoring is beneficial for selected patients with syncope, gastrointestinal hemorrhage, atrial tachyarrhythmias, and uncorrected electrolyte abnormalities. Finally, telemetry is not indicated for patients requiring minor blood transfusion, low risk chest pain patients with normal electrocardiography, and stable patients receiving anticoagulation for pulmonary embolism.** **© 2007 Elsevier Inc.**

□ **Keywords—electrocardiography; arrhythmia; telemetry**

INTRODUCTION

Historically, inpatient electrocardiographic (ECG) monitoring was simply used to track patient heart rate and underlying rhythm. More recently, telemetry has evolved into technological marvels that can detect complex dysrhythmias, myocardial ischemia, and prolonged QT intervals (1). However, because ischemia monitoring is absent or underutilized in many hospitals and evidence for QT interval monitoring is inconsistent, monitored, non-intensive care units are most often utilized for detecting life-threatening dysrhythmias and sudden death (1). Moreover, they are used for patients who might require frequent nursing care and monitoring, such as the demented elderly patient admitted for pneumonia or the patient requiring transfusion for gastrointestinal bleeding (Table 1) (2). When physicians do not systematically apply rigorous criteria for inpatient telemetry admissions, monitored beds quickly become unavailable and admitted patients are forced to wait in the Emergency Department (ED), contributing to ED overcrowding.

To establish some consistent criteria for telemetry admissions, the American Heart Association (AHA) published its comprehensive practice guidelines for ECG monitoring (1). These guidelines make specific recommendations for monitoring patients in telemetry units, based on available evidence or expert consensus opinion, and are especially useful when requests for telemetry beds overwhelm a hospital's monitoring capacity (e.g., the number of available ECG monitors, skilled medical personnel to interpret the ECG data). When 70% of the top 10 diseases admitted through the ED (Table 2) are clinically indicated for inpatient telemetry, hospitals with limited resources may easily be overwhelmed (3).

This article, therefore, examines the evidence behind admitting patients with common diagnoses to non-

Table 1. Common Diagnoses of Telemetry Unit Admissions (2)

Chest pain*
Congestive heart failure*
Acute coronary syndrome*
Hemorrhage
Arrhythmia*
Syncope*
Acute cerebrovascular disease*
Pulmonary disease/respiratory distress
Electrolyte disorders*
Febrile illness/sepsis

* Clinically indicated according to the AHA guidelines.

intensive care telemetry units. Although the AHA guidelines are comprehensive, they do not address several non-cardiac conditions that clinicians might often monitor on telemetry. Our discussion focuses on issues facing the practicing emergency physician from a very simple perspective: can this patient safely walk around the shopping mall without being monitored? If a patient's admission diagnosis and treatment plan do not increase his/her dysrhythmia risk above the general population (i.e., people walking around the mall), then he/she should not require telemetry monitoring simply because he/she is now in the hospital. For example, a patient with an implantable defibrillator who is admitted for cellulitis is not at a higher risk of a dysrhythmia than they were while they were shopping last week. Therefore, the mere presence of the defibrillator should not result in mandatory use of an unnecessary resource (telemetry). The placement of a patient in an available telemetry bed today might mean that another patient that may truly need a monitored bed tomorrow will be forced to spend an additional night in the ED. Telemetry beds should be used when indicated and not simply because they are available.

GOOD EVIDENCE FOR CARDIAC MONITORING

Patients whose Automatic Defibrillator has Fired

Implantable cardioverter-defibrillators (ICDs)/permanent pacemakers are often placed in patients with structural heart disease or ventricular arrhythmias to prevent sudden cardiac death (4). Early complications are typically procedure related, whereas generator (6%) or lead (12%) complications and inappropriate shocks (12–16%) may develop at any time (5,6). The most common reasons for hospital re-admission are ventricular arrhythmias (61%) and progressive heart failure (13%) (6). Patients whose defibrillator detected and appropriately fired for ventricular arrhythmias will require inpatient cardiac monitoring during the diagnostic evaluation and treatment of their arrhythmia; patients whose defibrillator fired inappropriately will require external monitoring while their device is being interrogated. However, once the device has been confirmed to be working appropriately, the patient no longer requires monitoring and can be moved to an unmonitored bed or discharged to home, unless there are other issues that may require telemetry.

Patients with Atrioventricular Block

Atrioventricular heart block (AVB) is classified into first-, second-, and third-degree heart block. Some patients may experience presyncopal episodes from bradycardia or ventricular arrhythmia, whereas others may be completely asymptomatic. The treatment of AVB depends on its likelihood of causing hemodynamic instability or degenerating into complete heart block.

Patients with complete heart block rely on ventricular escape pacemakers that are slow, often unstable, and unreliable (7). Because these rhythms may be nonperfusing, many patients with complete AVB are temporarily paced externally, but ultimately all will require permanent pacing (4). Therefore, they should be monitored while a search for reversible or treatable causes is performed, irrespective of the presence or absence of symptoms.

Second-degree AVB is sub-classified into Mobitz type I and Mobitz type II AVB. Mobitz type I AVB, often associated with inferior myocardial infarction, sclerodegenerative disease, myocarditis, and heightened venous tone (e.g., trained athletes, vomiting patients), may be reversible, whereas Mobitz type II AVB typically indicates some structural damage to the conduction system (8). Before 1991, Mobitz type I AVB was considered to be a benign condition that did not require permanent pacing unless patients developed symptomatic bradycardia. However, recent data suggest that patients with pacemakers had a higher 5-year survival rate than

Table 2. Top 10 Diagnoses of Hospital Admissions through the ED in 2002 (3)

Pneumonia
Congestive heart failure*
Chest pain*
Atherosclerosis/other heart disease*
Acute coronary syndrome*
Acute cerebrovascular disease*
Chronic obstructive lung disease
Arrhythmias*
Fluid and electrolyte disorders*
Affective or mood disorders

* Clinically indicated according to the AHA guidelines.

those without (76% vs. 70%). Moreover, over a third of patients with Mobitz type I AVB developed higher block, with 90% degenerating to complete heart block. Even in patients who were initially asymptomatic, more than 66% suffered complications of deteriorating conduction, symptomatic bradycardia, or premature death within 5 years (9). Therefore, unless their block is chronic and stable, all patients with Mobitz type I AVB should be monitored on telemetry.

Finally, Mobitz type II AVB always occurs below the AV node and is more likely than Mobitz type I to progress to complete heart block (8). Due to this risk, patients with chronic Mobitz type II AVB that are permanently paced have a higher survival rate than those without pacemakers (61% vs. 41%) (10). Until their block resolves or a pacemaker is placed, all patients should receive continuous cardiac monitoring. However, once they are successfully paced with an internal pacemaker, they no longer require monitoring. After all, patients with pacemakers regularly walk around the mall.

Patients with Prolonged QT and Associated Ventricular Arrhythmias

Torsade de pointes is an unstable ventricular tachycardia (VT) associated with a prolonged QT interval ($>$ 450 ms in women and $>$ 430 ms in men) (11). A variety of conditions, including drugs, electrolyte abnormalities, AVB, intrinsic heart disease, and cerebrovascular disease, can prolong the QT interval. Long QT syndrome in patients with ischemic heart disease, infants, and otherwise healthy young adults increases their risk of sudden cardiac death, presumably due to ventricular arrhythmias (12–14). These findings have been corroborated in longitudinal population studies, including one study in which 60% of sudden death cases were attributed to the prolonged QT interval (15,16). Sixteen percent of pediatric patients (aged $<$ 21 years) with suspected long QT syndrome had a ventricular arrhythmia noted on their initial ECG (14). Patients with prolonged QT intervals, polymorphic ventricular premature complexes (VPCs), or ventricular bigeminy on their ECG may develop longer runs and degenerate to ventricular fibrillation (VF) (1). These patients should always be carefully monitored.

Patients with Acute Heart Failure/Pulmonary Edema

Arrhythmias (e.g., atrial fibrillation [AF] with rapid ventricular response) may cause or result from acute decompensated heart failure. Stable heart failure patients who are admitted for rate or rhythm control of their arrhythmia should be monitored on telemetry to determine drug efficacy and prevent cardiovascular death (17). Patients should also be evaluated for adverse side effects, including thromboembolic events, bleeding (from concurrent anticoagulation), and worsening heart failure.

Telemetry monitoring is required for patients with severe heart failure that are treated with inotropic drugs that have proarrhythmic properties (e.g., milrinone, dobutamine) or are having their infusion rates adjusted (18–20). In a study of 60 patients with severe heart failure started on home milrinone after ICD placement, 7 of the 8 patients who developed a symptomatic arrhythmia had ICD firing (21). However, when patients on home infusions of inotropic drugs are admitted to the hospital for non-cardiac conditions and their infusion rates are not adjusted, it is not clear why they should be admitted to a monitored unit, particularly if they already have an internal defibrillator. It is also worth noting that the arrhythmogenic risk of inotropic agents is lower with nesiritide; treatment with nesiritide does not seem to increase a patient's risk of arrhythmias (18).

Patients Admitted for Acute Cerebrovascular Disease

ECG abnormalities are commonly seen in patients after acute cerebrovascular accidents, including AF, ST-segment, and T-wave abnormalities, QT-interval prolongation, AVB, and ventricular dysrhythmias. A randomized controlled trial of acute stroke patients showed a survival benefit in those admitted to monitored stroke units compared to unmonitored units. Furthermore, telemetry detected new onset AF in five patients and VF in one patient that was successfully resuscitated (22). In a study of 184 acute stroke patients where 60% had an abnormal admission ECG (including 23 patients with acute coronary syndrome [ACS]), 48-h telemetry identified a serious arrhythmia in 10 (5%) patients: two patients with type II AVB, one patient with transient third-degree AVB, seven patients with VF, and six patients with paroxysmal AF (23). Most recently, in a study of 1070 patients admitted for acute stroke symptoms (within 6 h of symptom onset), telemetry detected third-degree AVB in 114 (11%) patients, VT in 9 (1%) patients, AF in 97 (9%) patients, QT-interval prolongation in 66 (6%) patients, and ST-segment elevation in 50 (4.7%) patients (24). Because these arrhythmias require acute intervention, all patients with acute cerebrovascular events should be monitored on telemetry.

Patients with Acute Coronary Syndrome

Continuous cardiac monitoring is beneficial for patients with definite ACS (ST-segment or non-ST-segment elevation myocardial infarction) that have a significant risk of reperfusion arrhythmias. The incidence of ventricular arrhythmias is 7.5% after infarct (25). This is the subgroup of patients for whom intensive care units have been clearly shown to improve outcomes. Patients who develop VF or VT have higher in-hospital mortality than those who do not (25,26). Moreover, patients with elevated troponin levels, compared to those with normal troponins, are more likely to develop arrhythmias after percutaneous coronary interventions (27). In most hospitals, however, patients with ACS are monitored in an intensive care setting, particularly those with comorbidities, advanced age, or a complicated course.

Patients Requiring Massive Blood Transfusion

Massive blood transfusion is defined as the replacement of a person's entire blood volume (at least 10 units of packed red blood cells) within 24 h. Patients who receive massive blood replacement may develop hypocalcemia (94%) (28) and hypomagnesemia (both from citrate toxicity) that are significant enough to cause prolonged QT intervals and torsade de pointes (29,30). In one study, the mortality rate of patients with severe hypocalcemia was 71% (compared to 41% in those with normal calcium levels) (28). Furthermore, although hypomagnesemia alone is unlikely to cause dysrhythmias, it may potentiate the effects of concurrent hypocalcemia (29). Post-transfusion, even stable patients should be monitored on continuous telemetry until definitive therapy for their hemorrhage is instituted. Like ACS, patients who receive massive transfusions are usually monitored in the intensive care unit.

CARDIAC MONITORING MAY BE BENEFICIAL

Patients Evaluated for Syncope

Syncope patients with underlying cardiovascular disease, particularly congestive heart failure, have a poorer prognosis than patients without underlying cardiac disease or patients with unexplained syncope (31). One risk stratification study determined that the risk factors associated with clinically significant cardiac arrhythmias or death within 1 year include age over 45 years, abnormal ECG, history of heart failure, and history of ventricular arrhythmias. The incidence of arrhythmias is approximately 7%, 15%, and 46% in patients with 1, 2, and 3 or more risk factors, respectively (32). Therefore, patients with more than one risk factor may benefit from telemetry monitoring.

A more recent study of another risk stratification strategy (where patients with a history of congestive heart failure, an abnormal ECG on presentation, a complaint of shortness of breath, hypotension at triage [systolic blood pressure $<$ 90 mm Hg], and a hematocrit level less than 30%) identified 52 (7%) patients who had a serious outcome, including 23 (3%) arrhythmias. This strategy missed one patient whose syncopal episode was probably caused by a transient ischemic attack (33). Therefore, patients with multiple risk factors for an arrhythmic cause of their syncope may benefit from inpatient monitoring. Patients with a neurogenic etiology for their syncope (e.g., vasovagal syncope) or a normal ECG are low risk for dysrhythmias and have not been shown to benefit from monitoring.

Patients with Gastrointestinal Hemorrhage after Endoscopy

Life-threatening arrhythmias have been reported in patients with variceal bleeding after endoscopy, sclerotherapy, and intravenous vasopressin (34–38). Torsade de pointes may develop in patients after endoscopy due to the use of neuroleptic medications (for procedural sedation or agitation) or vasopressin (known to prolong the QT interval) or concurrent electrolyte abnormalities (e.g., hypokalemia or hypomagnesemia) (34). In addition, sclerotherapy using 5% sodium morrhuate can cause bradyarrhythmias requiring permanent pacemaker placement (35). Therefore, cirrhotic patients with variceal hemorrhage that received vasopressin or neuroleptics for procedural sedation may benefit from telemetry, particularly in the presence of electrolyte abnormalities. Telemetry monitoring should not be used to replace close medical monitoring and nursing care in patients with gastrointestinal bleeding from other causes.

Patients with Atrial Arrhythmias Receiving Therapy for Rate or Rhythm Control

Atrial tachyarrhythmias, specifically atrial fibrillation or atrial flutter with rapid ventricular response, are often treated with agents affecting rate or rhythm. Patients on beta-blockers, calcium channel blockers, or digoxin for rate control may benefit from telemetry to assess the efficacy of the drug to control the ventricular rate (1). Patients undergoing rhythm control with anti-arrhythmic drugs may also benefit from cardiac monitoring to detect

QT-interval prolongation and sinus node dysfunction from the proarrhythmic properties of these drugs (39). Recently, however, these requirements for inpatient monitoring were challenged by a study of patients with new-onset AF, which showed that out-of-hospital rhythm control with oral flecainide or propafenone may be efficacious and safe (40). Until more data support outpatient "self management" as the standard of care, telemetry monitoring may be beneficial for all admitted patients.

Patients with Electrolyte Imbalance

Disorders of potassium, calcium, and magnesium have been associated with life-threatening arrhythmias. Depletion of these electrolytes may potentiate the tachyarrhythmias observed in patients undergoing cardiac surgery, suffering from variceal bleeding treated with vasopressin, and receiving massive transfusion (29,34,41).

Hyperkalemia is often seen in patients with renal insufficiency or patients on angiotensin-converting enzyme inhibitors. Theoretically, elevated serum potassium may cause myocardial excitability and impair responsiveness to pacemaker activity, involving both atrial and ventricular pacing stimuli (42). Although severe hyperkalemia may cause atrioventricular dissociation and ventricular dysrhythmias, no life-threatening arrhythmias were reported in a recent Cochrane review of 12 clinical trials (43). ECG abnormalities are typically seen with serum potassium levels above 6.5 mmol/L, but normal ECGs have been reported in patients with levels above 9.0 mEq/L (44,45). Currently, treatment depends on the severity of the hyperkalemia and its effect on the ECG. Patients with ECG changes attributable to hyperkalemia require immediate management and may benefit from cardiac monitoring. However, in patients without any ECG changes, the threshold for emergent treatment is not so clear. Emergent treatment of levels above 6.5 mmol/L is recommended, even in the absence of ECG changes, so these patients should also be monitored accordingly (46).

Inadequate potassium, magnesium, and calcium can prolong the QT interval, which, as previously mentioned, increases the risk of ventricular arrhythmias and cardiovascular death. Moreover, a higher frequency of VPCs in patients with deficiencies in all three electrolytes have been reported, but very few sustained episodes of VT have actually been detected during monitoring (47–49). In particular, hypokalemia has been shown to increase the risk of arrhythmias in specific patients, for example, patients with underlying or concurrent heart disease and those with digoxin toxicity, suggesting that they may benefit from telemetry (50,51). Patients with ECG findings of prolonged QT should be monitored while their levels are corrected. For other hospitalized patients, however, there is no recommended threshold for monitoring patients in the absence of ECG abnormalities. Once electrolyte imbalances are corrected, monitoring is no longer necessary.

Patients with Subacute Congestive Heart Failure

Patients with subacute or mild congestive heart failure may benefit from continuous cardiac monitoring. In a study of 199 patients admitted with heart failure that were monitored on telemetry, the majority was monitored for a known arrhythmia (n = 82, 41%), followed by cardiac symptoms (n = 48, 24%) and electrolyte disturbances (n = 20, 10%). Although 83 (42%) patients had any abnormal telemetry recording, only a few patients had sustained VT (n = 11) or VF (n = 1). Telemetry guided treatment in 33 (17%) patients (52). Until there are more clinical trials that directly address this question, cardiac monitoring is likely to be beneficial during the inpatient management and diagnostic workup of these patients (1).

NO EVIDENCE FOR TELEMETRY MONITORING

Patients Requiring Blood Transfusion

Stable patients with acute or chronic anemia requiring blood transfusion do not benefit from cardiac monitoring. Life-threatening arrhythmias have been reported in patients who are transfused their entire blood volume from citrate toxicity, causing significant electrolyte abnormalities, particularly hypocalcemia (29,30). For most patients, the most common reaction—a febrile nonhemolytic transfusion reaction (1–5%), often manifested by fever, chills, and urticaria—is not detected by cardiac monitoring. Hemolytic reactions, though potentially life-threatening, are extremely rare (1:500,000) (53). There is no evidence that monitoring is necessary for patients being transfused a couple units of blood.

Patients Evaluated for Chest Pain

Chest pain patients admitted for suspected ACS represent the largest group of telemetry admissions. Although there are other reasons to hospitalize chest pain patients (e.g., stress testing, cardiac catheterization), the primary rationale for this liberal admission policy is that patients with acute ischemia may develop life-threatening dysrhythmias and require emergent intervention. Several

recent studies have questioned the utility of telemetry for these patients. In a prospective study of 467 patients admitted to a monitored unit, only 5 arrhythmias were detected: VF (n = 1), six-second pause (n = 1), supraventricular arrhythmias (n = 2), and non-sustained VT (n = 1) (54). Cardiac monitoring played no role in helping physicians determine which patients should be revascularized. Moreover, of the nine (1.9%) patients who died during the study period, three patients suffered VF or cardiac arrest. A follow-up study of 2240 patients showed that telemetry identified an arrhythmia in 19 (0.8%) patients who were transferred to the intensive care unit (54).

Other studies have identified a population at very low risk of adverse cardiac events. In Snider et al., monitoring identified four events in patients with atypical chest pain, a normal ECG, and normal cardiac markers, none of which were ventricular arrhythmias (55). Hollander et al. studied a cohort of chest pain patients with normal or non-specific ECGs, in which only four (0.9%) patients developed any arrhythmia (supraventricular tachycardia [n = 1], ventricular tachycardia [n = 1], and bradydysrhythmias [n = 2]) and no patients died during the study period (56). The addition of the Goldman risk score to this risk stratification scheme identified patients with a 0% risk of major cardiac complications, 0.3% of intermediate cardiac complications, and 0.3% of ACS diagnoses in one study and 0% risk of VF/VT or sudden death (56,57). Therefore, chest pain patients with an initial normal or non-specific ECG and normal cardiac markers have a less than 1% risk of life-threatening dysrhythmias, 0% risk of sudden death, and do not benefit from continuous cardiac monitoring.

Patients with Acute Exacerbation of their Chronic Obstructive Pulmonary Disease

The etiology of arrhythmias in patients with chronic obstructive pulmonary disease (COPD) is multifactorial, including hypoxemia, acidosis, electrolyte imbalance, underlying cardiac disease, and commonly used drugs (58). A meta-analysis of 191 randomized, placebo-controlled studies with over 6000 patients showed that long term beta-agonist use in patients with COPD increased the risk of adverse cardiovascular events, although there was no statistical difference in major events (VT, VF, syncope, congestive heart failure, ACS, cardiac arrest, and sudden death) (59). Short-term beta-agonist use in acute asthma exacerbations may slightly decrease potassium levels and increase QT intervals, but does not cause ventricular arrhythmias (60). In another study of 278 patients admitted for an acute COPD exacerbation, 20 (12%) patients developed an arrhythmia during the hospitalization, although only 4 patients had a ventricular arrhythmia (61). Even in patients who require bi-level positive pressure ventilation to treat their acute exacerbation, frequent VPCs and APCs were detected, but no ventricular arrhythmias were reported (62). Therefore, patients who are admitted for an acute COPD exacerbation are unlikely to benefit from cardiac monitoring, unless a cardiac etiology of their dyspnea is suspected.

Stable Patients with Pulmonary Embolism Receiving Anticoagulation

Patients with acute pulmonary embolism (PE) requiring anticoagulation are often admitted to monitored units. We found only one clinical trial that described the incidence of arrhythmias in 51 patients admitted for acute PE. Sinus tachycardia was present in 41 (80%) patients, followed by APCs (n = 8), VPCs (n = 6), AF (n = 6), and junctional rhythm (n = 2). No ventricular arrhythmias were detected (63). In addition, 20 episodes of cardiopulmonary arrest (all with pulseless electrical activity) were observed, of which three were successfully resuscitated. Before the arrest, initial ECG/telemetry showed a junctional rhythm in one patient and sinus rhythm in the remaining 19 patients.

More recently, studies have focused on the safety and efficacy of anticoagulating patients with acute PE or deep venous thrombosis (DVT) as outpatients with low molecular weight heparin. These patients are obviously not continuously monitored at home. In a study of 505 patients with PE and DVT treated as outpatients, 26 patients died, of which only two were attributed to a cardiovascular event (33). Wicki et al. attempted to derive a risk stratification score to identify patients at low risk for adverse outcomes, defined as major bleeding, recurrent thromboembolic events, and death (64). The presence or history of cancer and hypotension (systolic blood pressure $<$ 100 mm Hg) were assigned 2 points each and a history of heart failure or DVT, the presence of PaO_2 $<$ 8 kPa or DVT on ultrasound were each assigned one point. Patients with a composite score of $\leq$ 2 had a 2.2% risk of any adverse outcome, as compared to 26% in patients with a score of $\geq$ 3. Aujesky et al. identified patients with an even lower risk for adverse events (65). In their study of 15,531 patients with a discharge diagnosis of PE, low risk patients had a 30-day mortality rate of 1.5% and a cardiovascular complication (non-fatal cardiogenic shock or cardiopulmonary arrest) rate of 0.9%. This group consisted of patients $<$ 70 years old, with no previous history of cancer, heart failure, chronic lung disease, chronic renal disease, or cerebrovascular disease, and without any clinical features of tachycardia (heart rate $>$ 110 beats/min), hypo-

tension (systolic blood pressure < 100), altered mental status, and O_2 saturation $< 90\%$. Although these studies did not directly address the risk of arrhythmias, if these patients could be safely treated at home, then they should not require monitoring in the hospital.

CONCLUSION

Consensus guidelines have established criteria for a subset of patients who require inpatient continuous electrocardiographic monitoring, based on evidence and expert opinion. When physicians do not systematically apply these criteria for telemetry admissions, those resources can be easily overwhelmed. Based on the available literature, we categorized several common medical conditions based on their proarrhythmic risk to determine the benefit of inpatient monitoring.

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