

The Usefulness of Continuous ECG Monitoring in Risk Stratified Phase II Cardiac Rehabilitation Patients

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Abstract

Purpose: To determine the usefulness of continuous ECG monitoring during Phase II exercise training among a risk stratified population.

Methods: We conducted a retrospective 5-year review of 241 consecutive patients who underwent Phase II cardiac rehabilitation. Risk stratification, based on AACVPR criteria, resulted in 123 (51%) patients classified as low risk, 80 (33%) as intermediate risk, and 38 (16%) as high risk. The Phase II exercise records were then examined to identify individuals who had an "untoward event" during Phase II exercise training. An untoward event was defined as any problem that necessitated physician intervention or cessation of the exercise session. A total of 3,877 exercise sessions were reviewed.

Results: Ninety-nine untoward events occurred in a total of 69 patients. It was found that 24% of low, 34% of intermediate, and 34% of high risk patients had at least one significant event ($p > 0.05$). Of the 99 total events, 56 (57%) were initially detected through the use of CECG. Fifty-four events (55%) occurred within the first 2 weeks of program initiation, with 58% of those being detected by CECG. Overall, 57% of events resulted in a change in medical management of the patient. When events were detected solely by CECG, 39% resulted in a change in medical management, with equal percentages of patients within each risk strata receiving a change in treatment.

Conclusion: These results indicate that CECG may be useful for detecting abnormalities during cardiac rehabilitation, especially during the first 2 weeks of a Phase II program. When events are detected by CECG, they often result in a change in how a patient is treated. Also, it appears that based on current risk stratification criteria, it may be difficult to predict which patients will have untoward events during Phase II exercise training. Thus, excluding low or intermediate risk patients from cardiac rehabilitation seems unwarranted at this time.

Key Words: *Exercise Training*

The use of continuous ECG (CECG) monitoring is a controversial issue in Phase II cardiac rehabilitation. There appears to be a lack of consensus among cardiac rehabilitation providers as to the

extent to which ECG monitoring should be used. Some programs use continuous ECG monitoring during each session, while others use it on an intermittent basis. Those in favor of continuous ECG monitoring point to its potential benefit in detecting ischemia, potentially significant arrhythmias, or inappropriate heart rate responses (1). Those opposed to continuous ECG monitoring argue that the low incidence of cardiovascular complications during Phase II exercise training does not justify the cost and that patients can become psychologically dependent on monitoring to exercise safely (2).

Determining a patient's risk has been suggested to be helpful in determining the amount of monitoring needed (3). A position paper published in 1986 by the American College of Cardiology (4), suggests that monitoring should be limited to high risk patients (e.g., those with poor LV function, residual myocardial ischemia, or high grade ventricular ectopy), whereas recent guidelines published by the American Association of Cardiovascular and Pulmonary Rehabilitation recommend a graduated monitoring schedule in low, intermediate, and high risk patients (5). Implied in both sets of guidelines is that one can predict which subset of patients is more likely to have complications during Phase II exercise training and, thus, benefit from monitoring. At first glance, a study by Keteyian and colleagues (6) seemed to support this risk stratification concept as they found that high risk patients had more complications during exercise training compared to low risk patients. However, 86% of the complications seen in their study were either part of the patient's previous medical history or would have been identified without continuous ECG monitoring. There was no difference between low and high risk subgroups for the incidence of new-onset, asymptomatic events detected solely by ECG monitoring. Several other studies (7-9) concluded that the majority of both "minor" and "major" events occurred in low or intermediate risk patients and that ECG monitoring often resulted in a revision in

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medical management, regardless of risk classification. Thus, excluding low and intermediate risk patients from cardiac rehabilitation programs may place them in jeopardy if they choose to exercise on their own without proper supervision and guidance.

At present there are still limited and conflicting data that examines the cardiovascular complication rate and potential benefits of continuous ECG monitoring during Phase II exercise training among a risk stratified population. The purposes of this study, therefore, were to (a) retrospectively determine the usefulness of ECG monitoring for detecting complications during Phase II cardiac rehabilitation exercise and (b) to determine any differences in the incidence of abnormal responses in relation to risk categories.

Methods

This study was a retrospective chart review of 241 consecutive patients who participated in the Gundersen Lutheran Medical Center

(La Crosse, WI) outpatient Phase II cardiac rehabilitation program. Initially, the medical records of each patient were reviewed by the principal investigator. Data collected included cardiac history, clinical diagnosis, hospital course, left ventricular function, pertinent cardiac diagnostic testing results, medications, and exercise testing results. Based on this information, patients were stratified according to American Association of Cardiovascular and Pulmonary Rehabilitation (AACVPR) criteria (5). These criteria are presented in Table 1.

Patients typically entered the Clinic's Phase II program 2–3 weeks post event. All patients had either a low-level exercise test prior to hospital discharge or shortly thereafter or a symptom-limited exercise test before beginning the Phase II program. The exercise training program utilized a multistation format that included treadmill walking, stationary cycling, stair climbing, and upper body exercises such as rowing, a shoulder wheel, and arm ergometry. Sessions were held three times per week for 40–60 min per session.

Table 1
AACVPR Guidelines for Risk Stratification (5)

Lowest risk	Moderate risk	Highest risk
No significant LV dysfunction (EF > 50%)	Moderately impaired left ventricular function (EF = 40–49%)	Decreased LV function (EF < 40%)
No resting or exercise-induced complex dysrhythmias	Signs/symptoms including angina at moderate levels of exercise (5–6.9 METS) or in recovery	Survivor of cardiac arrest or sudden death
Uncomplicated MI; CABG; angioplasty, atherectomy, or stent; • absence of CHF or signs/symptoms indicating post-event ischemia	<i>Moderate risk is assumed for patients who do not meet the classification of either highest risk or lowest risk.</i>	Complex ventricular dysrhythmia at rest or with exercise
Normal hemodynamics with exercise or recovery		MI or cardiac surgery complicated by cardiogenic shock, CHF, and/or signs/symptoms of post-procedure ischemia
Asymptomatic including absence of angina with exertion or recovery		Abnormal hemodynamics with exercise (especially flat or decreasing systolic blood pressure or chronotropic incompetence with increasing workload)
Functional capacity \geq 7.0 METS*		Signs/symptoms including angina pectoris at low levels of exercise (< 5.0 METS) or in recovery
Absence of clinical depression		Functional capacity < 5.0 METS*
<i>Lowest risk classification is assumed when each of the risk factors in the category is present.</i>		Clinically significant depression
		<i>Highest risk classification is assumed with the presence of any one of the risk factors included in this category.</i>

*If measured functional capacity is not available, this variable is not considered in the risk-stratification process.

Starting exercise intensity was targeted at 10–30 beats above resting heart rate values, at 50–70% of heart rate reserve, or between 11–14 on the Borg scale of perceived exertion. Continuous ECG monitoring was used for all patients during each exercise session, and blood pressure was monitored at least once on each exercise modality.

Patients' exercise records were reviewed for number of exercise sessions completed, medications at the time of exercise, physiological responses during exercise (heart rate and blood pressure), untoward events that occurred during a Phase II visit, method of detection of events, and medical intervention resulting from said events. An untoward event was defined as any event that necessitated physician intervention and/or cessation of the exercise session and is consistent with the definition used by AACVPR in its program certification materials for documenting complications during cardiac rehabilitation. These included reports of chest/arm/shoulder discomfort, shortness of breath, dizziness, new arrhythmia or arrhythmia increasing with exercise, and abnormal resting or exercise heart rate or blood pressure responses. A change in medical management was defined as a change in medication, an alteration of the exercise prescription, hospitalization, or some other intervention (e.g., CABG, PTCA) that had a direct impact on the patient's clinical course. A clinic visit or further testing that did not ultimately alter patient care was not included as a revision of medical management.

Statistical Analysis

Standard descriptive statistics were used to define the subject population. Chi-square analyses were used to detect differences in the occurrence of events among the different risk groups. Alpha was set at 0.05 to achieve statistical significance.

Results

Data were collected on a total of 241 patients who participated in the outpatient Phase II program. Average age of the patients was 59 ± 10 years, and females comprised 20% of the participants. All patients had an entry diagnosis of percutaneous transluminal coronary angioplasty (PTCA), coronary artery bypass graft surgery (CABG), myocardial infarction (MI), valve surgery, or a combination of the above procedures. The majority of patients (80%) were

Table 2
Entry Diagnosis of Males ($n = 192$)
and Females ($n = 49$)
in the Phase II Program

	Males	Females
CABG	111 (58%)	23 (47%)
MI	50 (26%)	14 (29%)
CABG & MI	12 (6%)	5 (10%)
PTCA	3 (2%)	1 (2%)
Other	16 (8%)	6 (12%)
	192	49

post CABG or MI, with the percentages being similar between males and females (Table 2).

Patients were stratified into risk categories according to AACVPR guidelines. Overall, 51% of patients were classified as low risk, 33% as intermediate risk, and 16% as high risk, with the percentages being similar for males and females (Table 3).

A total of 3,877 exercise sessions were reviewed, with each patient participating in an average of 16 sessions (range of 1–36 sessions). A total of 99 untoward events occurred during the sessions reviewed. The type of event, frequency of occurrence, and method of detection, subdivided by risk category, are presented in Table 4. Of the 99 untoward events, 39 were experienced by low risk, 41 by intermediate risk, and 19 by high risk patients, respectively. Fifty-six (57%) of all events were initially detected through the use of continuous ECG monitoring. The remaining 43 (43%) were detected through blood pressure monitoring, abnormal signs and symptoms, or patient complaints. There was a significant difference ($p < .05$) in how events were detected among the three risk subgroups. Continuous ECG monitoring was responsible for detecting 24 of the 39 events in low risk patients (61%), 24 of the 41 events in intermediate risk patients (59%), and 8 of the 19 events in high risk patients (42%).

Table 3
Risk Categories of Male and Female Subjects
According to AACVPR Criteria

	Low	Intermediate	High
Male	97 (51%)	67 (35%)	28 (14%)
Female	26 (53%)	13 (27%)	10 (20%)
	123 (51%)	80 (33%)	38 (16%)

Table 4
Frequency and Type of All Events That Occurred
Within Each Risk Category

<i>Low risk</i>		
Type of event	Occurrences	Intervention
Non-ECG detected		
Resting hypertension	2	Medication change (2)
Exercise hypertension	2	Medication change (1) No change (1)
Exercise hypotension	1	Medication change (1)
Dizziness	3	Medication change (3)
Palpitations	1	Hospitalized (1)
Symptomatic atrial arrhythmia	1	Sent to E.R. (1)
Chest/arm pain	4	Medication change (3) No change (1)
Transient blindness	1	Clinic visit (1)
Detected with ECG monitoring		
Resting bradycardia	1	Medication change (1)
Resting tachycardia	3	Medication change (3)
High exercise heart rate	2	Medication change (2)
New atrial arrhythmia	3	Medication change (1) 12 lead (1) No change (1)
Supraventricular tachycardia	2	Increase fluids (1) Medication change (1)
New/increasing ventricular ectopy	7	Holter (3) No change (3) Clinic visit (1)
Ventricular tachycardia	6	Medication change (2) Echocardiogram (1) Holter (1) No change (2)
<i>Intermediate risk</i>		
Non-ECG detected		
Exercise hypertension	3	Medication change (3)
Dizziness	1	Medication change (1)
Nausea	1	Medication change (1)
Palpitations	2	Medication change (1) Lab work (1)
Chest pain/anginal equivalent	10	Medication change (5) Hospitalized (1) CABG (1) PTCA (1) Catheterization (1) No change (1)

Table 4
(continued)

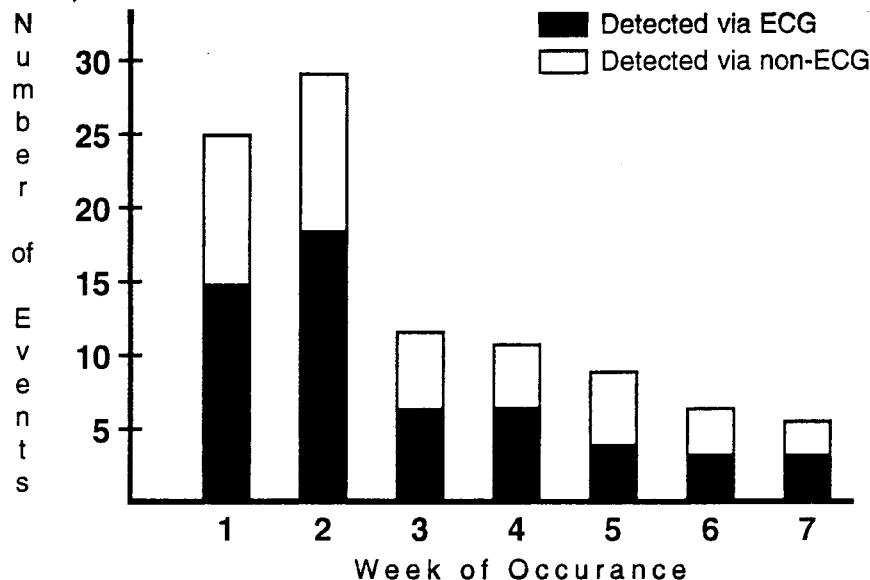
<i>Intermediate risk (continued)</i>		
Type of event	Occurrences	Intervention
Detected with ECG monitoring		
High exercise heart rate	4	Medication change (3) Lab work (1)
New atrial arrhythmia	5	Medication change (3) Sent to E.R. (1) No change (1)
Supraventricular tachycardia	1	Medication change (1)
New/increasing ventricular ectopy	6	Medication change (1) Lab work (1) Holter (2) No change (1)
Ventricular tachycardia	6	Holter (4) Admitted to CCU (1) Clinic visit (1)
ST segment changes	2	GXT (1) Clinic visit (1)
<i>High risk</i>		
Non-ECG detected		
Exercise hypertension	3	Medication change (3)
Dizziness	1	No change (1)
Shortness of breath	2	Pulmonary function testing (1) Adjust exercise prescription (1)
Chest pain/anginal equivalent	5	Medication change (1) Chest x-ray (1) CABG (1) Admitted to CCU (2)
Detected with ECG monitoring		
New/increasing ventricular ectopy	3	Holter (3)
Ventricular tachycardia	5	Hospitalized (2) Medication change (2) No change (1)

Of the 99 events, 54 (55%) occurred within the first 2 weeks of program initiation, with 31 (58%) of those events being detected through continuous ECG monitoring. The remaining 45 events occurred during weeks 3–7, with 52% being detected via continuous ECG monitoring (Figure 1). It should be noted that only 5 patients exercised beyond 8 weeks, and no new events or arrhythmia were detected after week 7.

When looking at individual patients, 69 of the 241 patients (29%) in the current study experienced at least one significant event during Phase II exercise training. It was found that 29 (24%) low risk, 27 (34%) intermediate risk, and 13 (34%) high risk patients had

at least one untoward event. Chi-square analysis revealed no significant ($p > 0.05$) difference in the proportion of patients within each stratified subgroup who experienced events. Twenty-one patients had multiple events during the rehabilitation program. There was also no difference ($p > 0.05$) in the proportion of patients within each stratified subgroup who had multiple events; 7% (9/123) were low risk, 10% (8/80) were intermediate risk, and 11% (4/38) were high risk.

Overall, 57 of 99 (57%) events resulted in a change in medical management of the patient. When events were detected only by ECG changes (i.e., no accompanying signs and symptoms or abnormal



◆ Figure 1 A comparison of the number of ECG and non-ECG events that occurred over the course of the study.

blood pressure responses), 22 of 57 (39%) events resulted in a revision in medical management. When events were detected by patient complaints or abnormal signs and symptoms, 35 of 42 (83%) events resulted in a change in medical management.

When looking at the benefit to individual patients, 44 patients (18% of total patients) had a revision in medical management as a result of an event that occurred during exercise training (Table 5). In 18 of those patients (7% of total patients), the event was previously unknown and was initially uncovered via ECG monitoring. There was no difference ($p > 0.05$) in the proportion of patients within subgroups who had a revision in medical management as a result of an event initially detected by CEKG. It can be seen, however, that there was a trend for more intermediate and high risk patients to have a revision in medical management if the event was detected by means other than CEKG.

Discussion

We detected a total of 99 events during Phase II exercise training that necessitated the stoppage of exercise or a call to the patient's referring physician. Fifty-six of these events were initially detected with continuous ECG monitoring. One of the major complaints surrounding the use of ECG monitoring is that it uncovers benign, nonsymptomatic arrhythmias that have no clinical significance and result in no change in medical management of the patient. In the current study, 39% (22 of 57) of the ECG identified events resulted in a change in medical management. These results are similar to those of Vongvanich and Merz (10), who found that 55% of telemetry ECG related calls altered patient care. The major care alteration in both studies was a change in medication.

Another way to assess the usefulness of ECG monitoring is to determine how many individual patients had a revision in medical

Table 5
Patients With ECG and Non-ECG Detected Events

	Low risk (n = 123)	Intermediate risk (n = 80)	High risk (n = 38)	All patients (N = 241)
# of patients with events	29 (24%)*	27 (34%)	13 (34%)	69 (29%)
# of patients with RMM**	18 (15%)	17 (22%)	9 (24%)	44 (18%)
Due to ECG	10 (8%)	5 (6%)	3 (8%)	18 (7%)
Due to non-ECG	8 (6%)	12 (15%)	6 (16%)	26 (11%)

*Numbers in parentheses represent the percentage of patients in that risk category.

**RMM = revision in medical management.

management resulting from a previously undetected abnormality. This approach is necessary since 21 patients in the current study had multiple events, and it could be argued that once those patients are initially identified, they should be monitored thereafter. It was found that 18 of the 241 patients (7%) in our study had a change in their clinical management as a direct result of continuous ECG monitoring. This rate is similar to that suggested by Greenland and Pomilla (1), who estimated that approximately 5% of individual patients would benefit from CECG during exercise training, but somewhat higher than the rates found by Keteyian and colleagues (6) and Mitchell and colleagues (11), who found that only 1.4% and 3% of newly determined, asymptomatic ECG events required intervention. Differences between studies probably relate to inclusion or exclusion of slightly different events, not having complete records regarding patient care alterations (10), or slight differences in how events were coded. With such low numbers of complications, a few differently coded events or care revisions can alter the percentages in the different subgroups or categories.

This study also found that continuous ECG monitoring was most useful for detecting abnormal responses to exercise during the first 2 weeks of the program. This is in agreement with studies by Mitchell and colleagues (11) and Fardy and colleagues (12). Mitchell and colleagues found that 12 of 177 cardiac patients developed arrhythmias during exercise training that were not evident during initial exercise testing. Eleven of the 12 (91%) abnormalities were detected during the first 3 weeks of the program. Similarly, Fardy and colleagues reported that recognition of new arrhythmias was 25% greater during the first 7 weeks compared to the final 5 weeks of a 12-week program.

A second purpose of the study was to investigate the incidence of significant cardiovascular events among the different risk subgroups. It has been suggested that risk stratification can aid in determining the amount of monitoring a patient with heart disease will need (3) and implies that it can be predicted which patients are more likely to experience an untoward event during cardiac rehabilitation exercise sessions. After risk stratifying our subjects according to AACVPR guidelines, we found no significant differences in the percentages of low, intermediate, and high risk cardiac exercisers who experienced an untoward event during cardiac rehabilitation. When looking at individual patients, 24% of low, 34% of intermediate, and 34% of high risk patients had at least one significant event. A closer examination of the data, however, does indicate that the type and severity of events were more complicated in the intermediate and high risk groups (Table 4). Whereas only 1 of 39 total events (3%) in the low risk group resulted in hospitalization, 5 of 41 events (12%) in the intermediate risk group required significant intervention (1 CABG, 1 PTCA, 1 cardiac catheterization, 1 hospitalization, and an admission to CCU). Five of 19 events (26%) in the high risk group resulted in a significant alteration in clinical course (4 admissions to CCU and 1 CABG). If these incidences are represented as a percentage of patients within each subgroup, 0.8% (1/123) of low risk, 6% (5/80) of intermediate risk, and 13% (5/38) of high risk patients had a "significant" alteration in care. These differences are probably related to a greater

degree of residual ischemia and LV dysfunction in the intermediate and high risk subgroups.

A broader implication of the above findings is that if low and intermediate risk patients had been denied access to supervised cardiac rehabilitation, 50% of the "major" complications requiring significant intervention would have been missed. Recently published studies by Paul-Labrador and colleagues (7) and Sanderson and colleagues (9) reached similar conclusions. Using AACVPR risk stratification criteria, Paul-Labrador and colleagues found that 67% of complications occurred in intermediate risk patients. If American College of Cardiology (ACC; 4), American College of Physicians (ACP; 13), or American Heart Association (AHA; 14) risk stratification criteria had been used in their study, 58–75% of patients with complications would have been classified as low risk and may not have been admitted to cardiac rehabilitation. Similarly, Sanderson and colleagues (9) found that 71% of major complications occurred in patients who fell into the AACVPR intermediate risk category.

Study Limitations

One obvious limitation of the present study is the retrospective nature of the data collection. While a retrospective design tends to eliminate the potential for treatment bias on the part of the researchers, such a design also is limited by the fact that the body of scientific knowledge changes as time progresses, and thus the opinions regarding the therapeutic treatment of certain conditions may also change over time (e.g., treatment of arrhythmias). Also, differences in how events were classified (e.g., major versus minor) as well as what constituted a revision in medical management varied tremendously between studies. Because the rate of complications during exercise training is relatively low, small changes in these parameters can greatly affect the statistical power of a study. These inconsistencies highlight the need for a multicenter, randomized trial comparing continuous ECG monitoring to nonmonitoring in a risk stratified population utilizing preset criteria concerning what constitutes an "event" and what constitutes a "revision in medical management."

Clinical Implications

Based upon the results of this study, it appears that continuous ECG monitoring is a useful tool for detecting arrhythmias or inappropriate heart rate responses during Phase II cardiac rehabilitation exercise sessions, especially during the first 2 weeks of the program. The events that were discovered with ECG monitoring were not felt to be benign by the patient's physician and resulted in a change in medical management 39% of the time. This benefit was consistent across all risk categories, as approximately 7% of patients within each risk strata had a revision in medical management as a result of an ECG detected abnormality.

While AACVPR guidelines may not delineate which patients are likely to benefit solely from ECG monitoring, they do appear to be helpful in identifying those patients at greater risk for an event requiring more substantial intervention. A higher percentage of

intermediate and high risk patients had an event that required either hospitalization or revascularization. These events were also more likely to be detected by non-ECG means.

In the current study as well as most previously published reports (6, 7, 14), subjects had undergone some sort of exercise testing before entering the Phase II program. Additionally, several of the studies enrolled patients from 1–4 months post event (14, 15). In the current health care arena, most patients are entering Phase II programs without any sort of exercise evaluation at all, and the goal is to get patients into the program as soon as possible. Therefore, the early use of ECG monitoring may be viewed as a valuable screening tool for arrhythmias or inappropriate heart rate responses that previously may have been detected with entry exercise testing.

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