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Holter Monitoring: Are Two Days Better Than One?

Seth McClennen, MD, Peter J. Zimetbaum, MD, Kalon K.L. Ho, MD, and Ary L. Goldberger, MD

Although continuous-loop event recorders are becoming the standard of care for the evaluation of intermittently symptomatic arrhythmias,[1–3] physicians continue to routinely order Holter monitoring (HM) for initial assessment of symptomatic and asymptomatic arrhythmias. A 24-hour monitoring period is usually selected, but limited data exist to support the optimal duration of HM. One study[4] has suggested that extending the monitoring period for evaluation of syncope could increase diagnostic yield. However, no published data are available concerning the incremental yield and cost effectiveness of a second consecutive 24-hour HM period in the evaluation of other symptoms. We performed a retrospective analysis of data from 164 consecutive patients referred for evaluation with 48-hour HM.

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From July 1992 to October 1998, we reviewed 48-hour HM of 164 patients referred to the arrhythmia monitoring laboratory in a tertiary care medical center. Primary indications obtained from the referring physician included palpitations, presyncope, syncope, evaluation of atrial fibrillation, and cerebral ischemic events.

The daily monitoring cost (1998 United States dollars), including monitoring equipment depreciation, laboratory technical staff, and the interpreting physician fee, was $300 per patient. Because the analysis of each daily HM report was performed independently, we assumed that the cost of a 48-hour monitoring period would be double the cost of a 24-hour monitoring period. Cost effectiveness was determined by the incremental cost divided by the incremental monitoring yield per day.

Each patient referral generated 2 separate 24-hour HM readings. Patients recorded all symptoms in a diary. Positive diagnostic outcomes were defined by (1) relevant symptoms in the presence or absence of arrhythmia, (2) potentially serious arrhythmias, or (3) other arrhythmias. Symptoms or arrhythmia on the second day of monitoring were only considered diagnostic if not previously documented on the first day of HM. A combined outcome for each 24-hour period was defined by the sum of the positive diagnostic outcomes listed above. Patients with both a new symptom and an unrelated new arrhythmia in the same 24-hour period were included only once in the combined outcome.

TABLE I Clinical Information (n = 164)

Baseline Characteristics	
Men/women	74 (45%)/90(55%)
Age (yrs)	
Mean ± SD	59 ± 19
Range	17–93
Indication	
Palpitations	60 (37%)
Presyncope/syncope	51 (31%)
Cerebral ischemic events	9 (5%)
Evaluation of atrial fibrillation	21 (13%)
Research protocol; other	23 (14%)

Arrhythmias defined as serious (or potentially serious) were atrial fibrillation and/or flutter, sustained paroxysmal supraventricular tachycardia (>15 seconds), nonsustained or sustained ventricular tachycardia, junctional rhythm with rate of <40/min or with symptoms, symptomatic sinus bradycardia with rate of <50/min, and complete or high grade second-degree atrioventricular heart block. Other arrhythmias included frequent ventricular premature depolarizations (>10/hour), multiform ventricular premature depolarizations, ventricular couplets, frequent atrial premature depolarizations (>200/hour), and atrioventricular Wenckebach rhythm. Arrhythmias were considered symptomatic if the patient recorded relevant symptoms at any time while the arrhythmia was present on HM recording.

Baseline patient characteristics of the study group are shown in Table I. Table II summarizes the symptom and arrhythmia outcomes in the study group. After 48 hours of HM, 74 of the patients (45%) remained asymptomatic. Sixty patients (37%) remained in sinus rhythm without ectopy or arrhythmia throughout the 48-hour monitoring period. During day 1, 96 patients (59%) were diagnosed with a new arrhythmia, compared with 8 patients (5%) on the

From the Division of Cardiology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts. This study was supported in part by grants from the Mathers Charitable Foundation, Mount Kisco, New York; the National Aeronautics and Space Administration (NAGW-5039), Washington, DC; and the National Institutes of Health/National Center for Research Resources (P41 RR13622), Bethesda, Maryland. Dr. Goldberger's address is: Cardiovascular Division, GZ-435, Beth Israel Deaconess Medical Center, 330 Brookline Avenue, Boston, Massachusetts 02215. E-mail: ary@astro.bidmc.harvard.edu. Manuscript received January 4, 2000; revised manuscript received and accepted March 22, 2000.

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TABLE II Monitoring Yield (n = 164)

Holter Monitor Outcome	Day 1	Day 2
New symptoms	74 (45%)	16 (10%)
New arrhythmia	96 (59%)	8 (5%)
Serious (or potentially serious)	31 (19%)	5 (3%)
Atrial fibrillation	14	3
Ventricular tachycardia	6	0
Paroxysmal supraventricular tachycardia	6	2
Junctional rhythm	3	0
Sinus bradycardia	1	0
High grade heart block	1	0
Other	65 (40%)	3 (2%)
Combined outcome of new symptoms or new arrhythmia	117 (71%)	23 (14%)

TABLE III Incremental Cost of Holter Monitor Outcome per Day (1998 US dollars)

Holter Monitor Outcome	Day 1	Day 2
New symptoms	$665	$3,075
New arrhythmia	$513	$6,150
Serious	$1,587	$9,840
Other	$757	$16,400
Combined outcome of new symptoms or new arrhythmia	$421	$2,139

second day. The most common arrhythmias included ventricular and atrial ectopy in 66 patients (40%), atrial fibrillation in 17 patients (10%), paroxysmal supraventricular tachycardia in 8 patients (5%), and nonsustained ventricular tachycardia in 6 patients (4%). Using the combined outcome of new symptoms and/or any new significant arrhythmia, 117 patients (71%) reached this end point on the first day compared with 23 patients (14%) on the second day.

Fourteen patients (9%) did not return diaries. The frequency of arrhythmia in these patients did not significantly differ from the rest of the study population. These patients were considered asymptomatic in the analysis.

Stratification by referral indication revealed that only 2 of 60 patients referred for general evaluation of palpitations were diagnosed with a new serious arrhythmia in the second 24-hour HM period (3% yield). This was comparable to 3 of 21 patients (14% yield) referred for specific evaluation of atrial fibrillation. No patients referred for syncope or cerebral ischemic events (n = 60) were diagnosed with a new serious arrhythmia during the second 24-hour monitoring period.

Table III shows the overall incremental cost of HM diagnostic outcomes per day. Further stratification by specific referral indication revealed that the incremental cost of diagnosing a new serious arrhythmia in patients being evaluated for possible atrial fibrillation increased from $450 for 24 hours of HM to $2,100 for 48 hours of HM. The incremental cost of diagnosing a new serious arrhythmia in patients referred for evaluation of palpitations increased from $3,000 to $9,000 with the addition of a second 24-hour HM period.

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This retrospective study, the largest to date to evaluate 48-hour HM, shows that in this population the incremental diagnostic yield of HM decreases significantly with a second day of monitoring. Although there was a high frequency of arrhythmias and symptoms in our study group, the arrhythmia frequency in this study appears comparable to previous case studies.[3–5] Because the incremental diagnostic yield falls off rapidly after 24 hours of monitoring and costs remain fixed, the cost effectiveness of a second 24-hour monitoring period is very low. A similar observation has been made for extending the duration of continuous-loop event recorder monitoring.[6]

We included all symptomatic patients in the positive result group because of the clinical utility of capturing symptomatic complaints that were not associated with arrhythmia. The high proportion (55% diagnosed by 48 hours) of symptomatic patients included using the combined end point elevated the number of positive studies. If subjective palpitations were excluded as a positive result in this analysis, 48-hour HM remained cost ineffective when compared with 24 hours. To diagnose any arrhythmia, the incremental cost increased from $513 for 24 hours of HM to $6,150 for 48 hours of HM.

In our study, only 5 patients were diagnosed with a serious new arrhythmia on the second day. Two patients had paroxysmal supraventricular tachycardia associated with intermittently symptomatic palpitations, a condition that may be more effectively evaluated with a continuous-loop event recorder.[2,3] The 3 patients with "new" atrial fibrillation were actually referred for evaluation of that condition, indicating that the referring clinician was aware of the diagnosis before the 48-hour HM result was known. Therefore, one possible limited use of more extended HM is the evaluation of known asymptomatic paroxysmal atrial fibrillation, if an initial negative 24-hour HM has been obtained.

Our study is limited by its retrospective design. Because 48-hour recordings comprised only 2% to 3% of all HM studies obtained in our institution, a prospective study would not have been time efficient. The present study is also limited by possible selection bias, because assignment to 48-hour monitoring was made by the referring physician and not by random assignment. The applicability of our results to the general population referred for HM is supported by the similar frequency of arrhythmia detection in previously published 24-hour HM studies.[3–5] However, a randomized prospective assessment of HM duration remains to be performed.

We conclude that in the population studied, 48 hours of HM is not cost effective when compared with 24 hours of HM, with the possible exception of evaluating asymptomatic paroxysmal atrial fibrillation.

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Effect of Hypertension on Cardiac Mass and Radial Artery Wall Thickness

Jean Jacques Mourad, MD, Olivier Hanon, MD, Xavier Girerd, MD, PhD, Pierre Boutouyrie, MD, PhD, and Michel E. Safar, MD

In the last decade, not only cardiac and carotid artery hypertrophy, but also radial artery hypertrophy, have been recognized in systemic hypertension.[1,2] The purpose of the present study was twofold: (1) to determine the level of cardiac and radial artery mass in subjects with essential hypertension, and (2) to evaluate which mechanical factor (mean arterial pressure, or pulse pressure, or a combination of both) may be considered to be a significant link between these 2 different cardiovascular structures.

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From June 1996 to June 1997, approximately 2,500 patients entered the Department of Internal Medicine of Broussais Hospital (Paris, France) for a cardiovascular prevention examination. From those patients, 300 never treated subjects (161 men and 139 women) with sustained essential hypertension were selected on the basis of previously described criteria.[3] High blood pressure (BP) was defined as systolic BP >140 mm Hg and/or diastolic BP >90 mm Hg, determined by arm cuff and mercury sphygmomanometer. Patients with a history of congestive heart failure, cerebrovascular, coronary or valvular heart disease, renal insufficiency (serum creatinine >200 μmol/L) or insulin- or non-insulin-dependent diabetes were not included in the study. Mean age and body mass index were 49 ± 14 years and 25.6 ± 4.3 kg/m^2 (mean ± 1 SD), respectively. The mean values for plasma glucose, total cholesterol, and creatinine were 5.9 ± 1.2 mmol/L, 5.6 ± 1.1 mmol/L, and 81 ± 16 μmol/L, respectively. Smokers represented 19% of the population.

The study was performed at 9 A.M. after blood fasting specimens were taken. Written consent was obtained from all the participants after a detailed description of the procedure. Casual BP was measured by sphygmomanometry with patients in the supine position after 10 minutes rest, using the first and the fifth phases of the Korotkoff sounds. Three consecutive measurements were performed by 1 physician and the average of the last 2 measures was used. Mean casual BP was calculated as diastolic BP + 1/3 (systolic BP − diastolic BP). Pulse pressure was calculated as systolic BP − diastolic BP. After casual determinations, semi-automatic noninvasive BP measurements were performed using the Dinamap 845 device (Criticon Inc, Tampa, Florida). This device was set to automatically inflate every 3 minutes.[4] Ten automatic measurements were recorded on a printer and the average of the last 5 measurements was considered to be the BP.

Because aortic pulse BP is physiologically lower than brachial pulse BP for the same mean arterial BP,[5] we established a nomogram, allowing for calculation of aortic pulse pressure from the determinations of brachial systolic and diastolic BP using the Dinamap measurements. Previously published data[6] indicated the individual values of age, intra-aortic systolic and diastolic BP, and brachial systolic and diastolic BP (mm Hg) measured by Dinamap. From these data, we established the following equations: systolic BP (aorta) = 1.12 systolic BP (Dinamap) − 17, and diastolic BP (aorta) = 0.97 diastolic BP (Dinamap) − 0.32. From the 2 nomograms, aortic pulse pressure was deduced. All the subjects (n = 300) underwent an evaluation of radial artery parameters by ultrasound, whereas 80 subjects had concomitant echocardiographic measurements using standard techniques.[7,8]

The high resolution echo-tracking device used for radial artery measurements at the wrist has been previously described and validated in humans.[9] Arterial diameter and posterior wall thickness were measured when a "double peak" radiofrequency ultrasound signal of the anterior and posterior walls was obtained.[1,2] Short-term intraobserver repeatability was 2.8% and 5.1% for internal diameter (D_i) and intima-media wall thickness (h) measurements, respectively.[1] The wall cross-sectional area (square millimeters) was calculated as $(3.14D_e^2/4) - (3.14D_i^2/4)$, with D_e as the external diameter, and the radius-thickness ratio as $D_i/(h \cdot 2)$. Because of the incompressibility of the arterial wall, the radial artery mass was more appropriate to calculate than wall thickness itself,[10] and was expressed in milligrams per centimeter. Measurements of both left ventricular (LV) and radial artery

From the Department of Internal Medecine, Broussais Hospital, Paris, France. Dr. Safar's address is: Médecine Interne 1, Hôpital Broussais, 96 rue Didot, 75674, Paris Cedex 14, France. E-mail: michel.safar@brs.ap-hop-paris.fr. Manuscript received December 27, 1999; revised manuscript received and accepted March 24, 2000.

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