Predictive use of routine 24-hour electrocardiography in suspected Adams-Stokes syndrome

Comparison with cardiac rhythm during symptoms

NILS-JOHAN ABDON, BENGT W JOHANSSON, JAN LESSEM

From the Section of Cardiology, Medical Department, Malmö General Hospital, Malmö, Sweden

SUMMARY Using strictly defined criteria of significant arrhythmias, long term electrocardiographic recording has been evaluated for confirmation of arrhythmias as the cause of cerebral symptoms in 81 patients with suspected Adams-Stokes syndrome.

Extension of long term electrocardiographic recording for more than 24 hours gives marginal additional information at a high cost. Among 43 patients monitored until symptoms appeared, non cardiogenic causes were confirmed in 20 of 22 patients because the recording showed normal rhythm during symptoms. Fifteen of 21 patients with a significant arrhythmia during an asymptomatic 24 hour recording later had the same arrhythmia during symptoms.

Of 38 patients who failed to develop symptoms, 21 had a significant arrhythmia detectable within 24 hours and 23 when 48 hours of recording were analysed.

Long term electrocardiographic recording has disclosed that 20 to 75% of patients with suspected Adams-Stokes syndrome have serious arrhythmias known to or presumed to correlate with cerebral symptoms.¹⁻²² The varying rates of positive findings might be explained by differences in patient selection. Variations in duration of long term electrocardiographic recording and criteria for serious arrhythmias should also be considered. Lopes *et al.*²³ observed a moderate increase in ectopic beats while Jonas *et al.*¹³ observed an increase in pertinent arrhythmias from 14 to 23% as long term electrocardiographic recording was extended from 12 to 24 hours. Kennedy *et al.*,²⁴ however, found that most instances of ventricular arrhythmias were correctly graded within 24 hours. Less is known about the increased detection of bradycardias as long term electrocardiographic recording is prolonged, but Tzivoni and Stern²⁵ reported that most cases with bradycardias severe enough to require pacemaker treatment were detected within 24 hours. Prolongation of long term electrocardiographic recording until symptoms appear may establish a temporal relation between arrhythmias and symptoms or it may rule out the Adams-Stokes syndrome by recording a normal cardiac rhythm during symptoms.

The main purpose of the present study is to compare the cardiac rhythm during symptoms with the arrhythmias detected during a 24 hour long term electrocardiographic recording using strict criteria for significant arrhythmias. In patients who failed to develop symptoms we determined the increase of serious arrhythmias detectable by prolonging long term electrocardiographic recording from 24 to 48 hours.

Patients and methods

Each year about 1300 patients are referred to the Section of Cardiology because of suspected Adams-Stokes syndrome. Regardless of previous electrocardiographic findings all of them are subjected to a routine 24 hour electrocardiographic recording.

This study included 81 patients aged 15 to 86 years (mean $61 \pm \text{SD}16$) suspected of having Adams-Stokes syndrome. During a four month period they were all selected because of weekly or more frequent attacks of syncope ($n=17$), dizziness including presyncope ($n=45$), or both ($n=19$). All patients had consented to wear an electrocardiographic tape recorder until symptoms had occurred and were expected to keep a diary noting the time of symptoms. Patients with recent changes in their cardiac medication were excluded. An examination was performed before the study in order to detect possible non-cardiac causes of

symptoms. All patients participated for at least 48 hours but 38 patients terminated recording before symptoms because of subjective discomfort.

A previous myocardial infarction was suffered by eight patients while seven others were treated with digitalis and/or diuretics because of heart failure. Seventy-three patients were in sinus rhythm and had no pertinent arrhythmias detectable in their routine 12 lead electrocardiograms. One patient had atrial fibrillation with appropriate ventricular rates, while six had sinus rhythm plus ectopics or episodes of tachycardias, and one had a bradycardia of 50 beats per minute (bpm) or less (sinus bradycardia).

LONG TERM ELECTROCARDIOGRAPHIC RECORDING

Long term electrocardiographic recording was performed using portable electrocardiographic tape recorders type SRA/HRB-3 (Helcomed Norden/Hellige). The patients revisited the Section of Cardiology every second day for a technical check-up.

SCREENING OF ELECTROCARDIOGRAPHIC TAPES

The tapes were screened by one of two automatic units. One unit writes out all rhythms corresponding to rates faster than 120 or slower than 40 bpm, detected by a single RR interval, as a one-channel electrocardiogram on a paper strip. Write-out from the other unit is triggered by an increase or decrease of the cycle length of 30% or more of the average from the last minute of recording. In addition, both units write out every 10th ventricular extrasystole occurring within one minute of recording as detected by QRS configuration criteria. All electrocardiographic write-outs were screened by a specialised laboratory technician and one of the authors (N-J A).

CLASSIFICATION OF ARRHYTHMIAS

Arrhythmias known or presumed to correlate with cerebral symptoms were termed *significant*. Minor arrhythmias expected to occur in asymptomatic elderly subjects were classified as *insignificant* and omitted from this presentation.

The criteria of significant arrhythmias were based on the findings made when 103 elderly subjects (mean age 71 ± 11 years) selected at random from the general population were examined by 24 hour long term electrocardiographic recording using the same equipment and screening limits.²⁶ The following arrhythmias were termed significant: frequent ventricular extrasystoles whenever one was followed by a second ventricular extrasystole within no more than five beats and this second extrasystole was followed by a third extrasystole within no more than five complexes, potentially dangerous extrasystoles²⁷ being observed separately; atrial tachycardias at a rate of $\geq 120/\text{min}$

and duration >8 s. The sick sinus syndrome was diagnosed according to one or more of the following criteria: (1) Sinus bradyarrhythmias ≤ 50 bpm and with a variation in consecutive PP intervals of $\geq 20\%$; (2) regular sinus bradycardia ≤ 45 bpm when awake; (3) sinoatrial block; and (4) sinus arrests of ≥ 1.5 s. The lowest rates were calculated from a sequence of three or more beats of the basic rhythm. Patients with the sick sinus syndrome and additional episodes of atrial tachyarrhythmias were considered to have the bradycardia-tachycardia syndrome.

Second and third degree atrioventricular block was always significant. In atrial fibrillation third degree block was designated if the ventricular rate, as calculated from three or more consecutive beats, was ≤ 40 bpm or 41 to 50 bpm with a QRS morphology different from that of conducted beats.

Results

The 81 participating patients were divided into two groups. One group consisted of 43 patients who tolerated long term electrocardiographic recording until symptoms appeared and one group of 38 patients terminating long term electrocardiographic recording at varying times ≥ 48 hours but before symptoms. Examination continued for two to 21 days (mean four).

PATIENTS WITH SYMPTOMS DURING LONG TERM ELECTROCARDIOGRAPHIC RECORDING

Among the 43 patients with symptoms 28 had syncope or dizzy spells. In 15 patients the symptoms during recording were cardiac but often connected with a sensation of pending collapse or associated with the onset of typical cerebral symptoms.

The arrhythmia diagnoses during the 24 hour periods and the number of patients with symptoms are shown in Table 1 together with patients with a normal rhythm during symptoms.

During the asymptomatic period 22 patients had no significant arrhythmias. A non-cardiac cause of their symptoms could be confirmed in 20 (91%) patients who had no significant arrhythmia during the entire 24 hour period during which symptoms occurred. Two patients lacking significant arrhythmias during the initial 24 hour period had atrial tachyarrhythmias when symptoms later developed (Table 1).

Twenty-one patients had significant arrhythmias suggesting a cardiac origin during the asymptomatic period. When symptoms appeared it was confirmed that the same arrhythmia previously recorded was related to symptoms in 15 (71%) of them. Furthermore, one patient with atrial tachyarrhythmias both initially and during symptoms had episodes of sinus bradycardia unrelated to symptoms during the same

Table 1 Patients examined by long term electrocardiographic recording until appearance of symptoms: Comparison of arrhythmia diagnosis from routine 24 hour recording with recordings when symptoms occurred

Arrhythmia diagnosis	Asymptomatic (routine) 24 hour period	Symptomatic 24 hour period		Patients with normal rhythm symptoms
		Same arrhythmia	Other arrhythmia	
Not significant	22	20	2 (atrial tachyarrh)	20
Atrial tachyarrhythmias	7	6	1 (SSS)	2
Sick sinus syndrome:				
Brady-tachy	6	6	0	1
Brady only	1	1	0	1
Atrioventricular block, third degree	1	1	0	0
Frequent ventricular extrasystoles	2	2	0	1
Couplets ventricular extrasystoles/ventricular tachycardia	4	4	0	1

24 hour period in which symptoms occurred. This allowed the correct diagnosis of a bradycardia-tachycardia syndrome.

In six of the 21 patients who had significant arrhythmias during the initial period, symptoms did not occur simultaneously with the arrhythmias. One of these patients, however, later reported the disappearance of cerebral symptoms after pacemaker implantation and three reported the disappearance of symptoms on antiarrhythmic medication.

In 13 of the 15 patients with simultaneous arrhythmias both initially and during later symptoms the arrhythmias observed in connection with symptoms were of the same type and severity as those previously observed during the asymptomatic period. Notable aggravations of pre-existing arrhythmias were observed in only two cases as they fainted: one with couplets of ventricular extrasystoles developed ventricular tachycardia and one with third degree atrioventricular block had an asystole of 21 seconds.

A new type of additional significant arrhythmia was discovered during the period in which symptoms occurred in three patients. They had frequent ventricular extrasystoles temporarily unrelated to symptoms.

Use of less strict criteria for significant arrhythmia

Among the 20 patients with no significant arrhythmia at any time during the recording (including during symptoms—Table 1) eight had moderately frequent ectopic beats, two had atrial tachyarrhythmias lasting for a few seconds unrelated to symptoms, and four had a perfectly regular sinus bradycardia at the time of sleep. Among six patients with a bradycardia related to symptoms, three had moderately frequent ectopic beats and two had tachyarrhythmias lasting for a few seconds without relation to symptoms.

PATIENTS WITHOUT SYMPTOMS DURING LONG TERM ELECTROCARDIOGRAPHIC RECORDING

Thirty-eight patients had no symptoms during monitoring. Nineteen had no significant arrhythmias

during the initial 24 hour period, 18 (95%) of them remaining free from significant arrhythmias when long term electrocardiographic recording was extended to 48 hours. The one patient discovered by prolonging the period of recording had atrial tachyarrhythmias, and the remaining five patients with atrial tachyarrhythmias were discovered within 24 hours of long term electrocardiographic recording. All eight patients with the sick sinus syndrome, all three with second or third degree atrioventricular block, and both patients with ventricular arrhythmia were detected during the first 24 hours of recording. Three patients, however, with significant arrhythmias during the first 24 hours had the additional finding of ventricular arrhythmia as long term electrocardiographic recording was extended from 24 to 48 hours (Table 2).

Discussion

The clinical management of patients with cerebral symptoms and episodic cardiac arrhythmia has of necessity been empirical unless a temporal relation between arrhythmias and symptoms could be established. The present study investigated the adequacy of a routine 24 hour electrocardiographic recording using strict criteria for significant arrhythmias by comparing the arrhythmias initially present with the cardiac rhythm during later symptoms.

ARRHYTHMIAS DURING INITIAL (ROUTINE) 24 HOURS VERSUS RECORDINGS DURING SYMPTOMS

Among the 43 patients with electrocardiographic recordings until symptoms appeared, the asymptomatic periods included no significant arrhythmia in 22. By recording the cardiac rhythm during symptoms a non-cardiac cause of symptoms could be confirmed in 20. Thus, with the presently used classification of significant arrhythmias a negative routine 24 hour long term electrocardiographic recording gave a 91% prediction that the rhythm during symptoms would be normal.

Table 2 Patients without symptoms during monitoring: comparison of arrhythmia diagnosis (significant arrhythmias only) present during initial 24 hour period with arrhythmia diagnoses when second 24 hour period included

Arrhythmia diagnosis	From initial 24 hour period	With second 24 hour period included		New additional significant arrhythmia
		Same	Other	
No significant arrhythmia	19	18	1 (atrial tachy)	
Atrial tachyarrhythmias	5	5	0	1 ventricular extrasystoles
Sick sinus syndrome				
Brady-tachy	4	4	0	1 ventricular extrasystoles
Brady only	4	4	0	
Atrioventricular dissociation	1	1	0	
Atrioventricular block second/third degree	3	3	0	1 ventricular extrasystoles
Frequent ventricular extrasystoles, couplets	2	2	0	

When the 24 hour recording suggested that arrhythmia was the cause of symptoms this was confirmed in 15 of 21 patients (71%) by recording the same arrhythmia during symptoms. Four of six patients, however, with significant arrhythmias not coinciding with symptoms improved on antiarrhythmic therapy. This improvement may have been spontaneous and the cause was not investigated further. Hence a routine 24 hour recording with significant arrhythmia was either confirmed or, using the terminology of Ward *et al.*,²² clinically useful in 90% of the cases.

The management of patients with significant arrhythmias is frequently based on the presumption that the arrhythmias documented are the antecedents of more serious arrhythmias. Among our 15 patients with simultaneous arrhythmia and symptoms this was only observed in two. The remaining 13 patients showed a varying response to the same arrhythmia.

Three previous reports^{16 19 22} have demonstrated temporal relations between arrhythmias and cerebral symptoms in less than 10% of patients, while other reports showed from 13 to 76%, but a considerable number of patients have no significant arrhythmia at any time of the recording including during symptoms. There is little doubt that the former deserves treatment for arrhythmias and that a non-cardiac cause should be sought among the latter. More difficult is how to treat patients with significant arrhythmias unrelated to time of symptoms. It is worth while noting that four of six such patients in this series may later have responded to treatment. Conversely in another series 35 out of 44 (80%) patients without treatment for significant arrhythmias had persisting cerebral symptoms.²⁸

There are several possible explanations for the lack of correlation between arrhythmias and symptoms in patients who may really have the Adams-Stokes syndrome. As pointed out before¹³ temporary impairment of memory is part of the disorder. There may be

failure to report symptoms,¹⁸ the incorrect timing of events, or difficulties in obtaining adequate diaries.^{5 13 20 22}

A major reason for lack of correlation between arrhythmias and symptoms may be a broader definition of significant arrhythmias. The report of Clark *et al.*¹⁹ with a low incidence of patients with temporal relation between symptoms and arrhythmia may be illustrative of this, since the same group also provided a detailed report of the application of their criteria for significant arrhythmias in an elderly asymptomatic population of 13 subjects.²⁹ No less than 10 of these 13 subjects had "significant" arrhythmias. With the criteria currently used only nine of 77 asymptomatic elderly subjects²⁶ had significant arrhythmias. Correspondingly, a high rate of positive correlation with later symptoms was obtained in this series.

PATIENTS WITHOUT SYMPTOMS DURING RECORDING

Eighteen of the 19 patients with an initial 24 hour recording remained free from significant arrhythmias as long term electrocardiographic recording was extended from 24 to 48 hours. Among the 19 patients with significant arrhythmias during the initial 24 hour period three had an additional type of significant arrhythmia during the second period; the arrhythmia was ventricular in all three. Thus, the originally detected types of significant arrhythmia were confirmed as the only ones in 84% of those having significant arrhythmias during the initial 24 hour period.

Remarkably little is known about the increased detection of all types of significant arrhythmias attainable by prolongation of long term electrocardiographic recording. Lopes *et al.*²³ and Jonas *et al.*¹³ reported that extension of long term recording from 12 to 24 hours resulted in considerable increases in ventricular or pertinent arrhythmias, respectively.

Kennedy *et al.*²⁴ found that the overwhelming majority of ventricular arrhythmias were detected within 24 hours when a comparison with additional days of recording were made. Among the entire series of 81 patients we noted that 19 of 20 cases with bradyarrhythmias were detected within 24 hours, but three of 14 patients with atrial tachyarrhythmias required prolonged monitoring for their detection.

COMPARISON WITH ASYMPTOMATIC POPULATIONS

In patients not experiencing symptoms during long term electrocardiographic recording the evaluation may be assisted by comparison with findings reported from asymptomatic populations.

Several investigations³⁰⁻³⁴ have shown that almost every young, middle-aged, or elderly individual will have some type of cardiac arrhythmia when the electrocardiographic recording is continued for a sufficient time. A further analysis, however, discloses that sinus bradycardia is extremely common in young subjects,³¹⁻³³ while it is rare among elderly subjects.³⁵

Seemingly in contrast with these more or less epidemiological investigations some clinically active centres have found that serious episodic arrhythmias are rare among selected normal elderly subjects.¹⁴⁻³⁵⁻³⁶ This centre reported the findings when 103 elderly subjects selected at random from the general population were examined by 24 hour long term electrocardiographic recording.²⁶ Twenty-six of them admitted syncope and/or dizziness while 77 did not. Twelve of the 26 symptomatic and nine of the 77 asymptomatic subjects had significant arrhythmias according to the classification currently used ($p < 0.001$). This may explain why so many of our patients had coinciding significant arrhythmias and symptoms. The use of strict criteria derived from the population study may also explain the high degree of prediction achieved from an asymptomatic 24 hour recording.

ECONOMIC ASPECTS

The costs involved in extended recording were impressive when related to the additional information obtained. Each new case of significant arrhythmia cost 5.7 times that of a significant arrhythmia discovered during routine recordings. Facilities for long term electrocardiographic recording are limited and we have chosen to screen a large group of patients with possible Adams-Stokes attacks³⁷ with a 24 hour electrocardiogram rather than to concentrate resources on a small group of patients.

Conclusions

We conclude that the routine 24 hour long term elec-

trocardiographic recording will be sufficient to detect most patients with Adams-Stokes syndrome. When strictly defined criteria for significant arrhythmias are applied, the need for recording until symptoms occur will be reduced. Prolonged monitoring should be used principally in patients with problems of differential diagnosis or when there is strong evidence of the Adams-Stokes syndrome despite an initial negative recording. Provided that long term electrocardiographic recordings are interpreted with an open mind, the routine application of a 24 hour period should be acceptable, with the understanding that prolonged monitoring may be needed exceptionally.

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Requests for reprints to Dr Nils-Johan Abdon, Section of Cardiology, Medical Department, General Hospital, S-214, Malmö, Sweden.