Atrial function after cardioversion for atrial fibrillation

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Twenty-four patients with sinus rhythm following cardioversion performed to correct atrial fibrillation were examined by kinetocardiography; the a wave was measured in order to study the atrial contraction and its correlation with the duration of the sinus rhythm examined. In recordings made immediately after cardioversion and again 24 hours later, one patient showed no signs of contraction of either atrium, one showed no signs of contractions of the right atrium, and a third no activity of the left atrium. The majority of other patients showed higher relative amplitudes than normal persons. Classification of patients according to the duration of sinus rhythm revealed a correlation between this and the relative amplitude of the a wave. This correlation is analysed and an interpretation suggested. After cardioversion the kinetocardiogram thus provides a simple and reliable method for assessing the atrial contraction and the likely duration of the sinus rhythm.

That the absence of atrial contraction in cases of atrial fibrillation is of considerable haemodynamic importance, is well known. On the one hand, the filling of the ventricles is reduced, with a resultant fall in the stroke volume; on the other, incomplete evacuation of the left atrium favours the formation of thrombi and arterial emboli. Moreover, closure of the AV valves is adversely affected. For all these reasons, it is desirable to re-establish the sinus rhythm. The simplest manner of effecting this is by means of cardioversion.

When the electrocardiogram confirms the presence of sinus rhythm, cardioversion may be considered to be successful. It cannot be assumed, however, that the mere presence of sinus rhythm immediately following cardioversion indicates that atrial function has been restored to normal. Indeed, several authors believe that, in the hours after cardioversion, mechanical function may still be inadequate or even completely lacking, despite a normal electrical function (Logan *et al.*, 1965; Rowlands, Logan, and Howitt, 1967). This may apply to one atrium alone, or to both together. Thus, the pulmonary oedema described as occurring shortly after cardioversion is believed to be the result of an isolated mechanical insufficiency of the left atrium (Resnekov and McDonald, 1965). Proof of this is allegedly provided by the pressure curves of the right and left atria obtained by catheterization —

curves that reveal either low a waves or even none whatever.

So far there does not appear to be a single important study giving details of the incidence of insufficient atrial contraction after so-called successful cardioversion. Nor is it known whether any correlation exists between the force of atrial contraction observed immediately after cardioversion and the duration of the sinus rhythm established. These questions can partly be elucidated by means of kinetocardiography, a noninvasive method that is both simple to perform and less trying to the patient than the use of the cardiac catheter. The kinetocardiogram represents the absolute movements of the chest wall produced by the action of both sides of the heart (Eddleman *et al.*, 1953). In as much as the a wave of the kinetocardiogram corresponds chronologically to the contraction of the atria, its presence provides evidence of the mechanical function of the left and right atrium. The present study describes the behaviour of the a waves in patients after successful cardioversion from atrial fibrillation. The possible correlation between the a wave immediately and 24 hours after cardioversion and the duration of the sinus rhythm were also studied.

Subjects and method

The study includes 24 patients successfully subjected to cardioversion. The first group (A) comprised 10 patients who had previously undergone heart operations of various kinds (6 mitral valve replacements, 2 mitral

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commissurotomies, 1 aortic valve replacement, and 1 closure of an atrial septal defect). The second group (B) comprised 12 patients with idiopathic atrial fibrillation and 2 others with treated hyperthyroidism. The kinetocardiogram was recorded immediately after cardioversion and again 24 hours later. Recordings were made as usual at the end of an expiration, using the following points in the Eddleman *et al.* (1953) scale: $K_{sternum}$, K_{24} , K_{34} , K_{44} , and K_{35} .¹

The electrocardiogram and phonocardiogram were recorded simultaneously. In measuring the kinetocardiogram, the height of the a wave was calculated and then converted to a percentage of the overall deflection (relative amplitude). Since this value differs somewhat from one recording point to the next, it was decided to calculate the mean values of the left-sided (K_{34} , K_{44} , K_{35}) and the right-sided ($K_{sternum}$, K_{24} , K_{34} , K_{44} , K_{35}) waves, and to use these in all subsequent measurements. In order to simplify calculation of the changes in the a wave occurring during the first 24 hours, the mean value obtained from all recording points ($K_{sternum}$, K_{24} , K_{34} , K_{44} , K_{35}) was calculated and the change expressed as a percentage of the original (i.e. immediately after cardioversion) value. Subsequently, these values (i.e. the left-sided and right-sided a wave both immediately and 24 hours after cardioversion, plus the alteration expressed in percentage of the original value) were correlated with the duration of the sinus rhythm established, and examined for their prognostic significance. For this purpose, patients were kept under surveillance for a period of not less than 8 months, and divided into 2 groups, depending on the duration of the sinus rhythm. A duration exceeding 8 months was classified as long-term result; where the

¹ In Eddleman's system, the first figure indicates the vertical line corresponding to V1-6, and the second figure the relevant intercostal space.

FIG. 1 The duration of the sinus rhythm established. Above the 18 patients (7 of group A, 11 of group B), who received quinidine; below the 6 patients (3 of group A, 3 of group B) without quinidine. ● sinus rhythm (SR) till the end of the observation period. x indicates the beginning of renewed atrial fibrillation (AF). The broken line separates long-term and short-term results.

period was less than 8 months, the result was classified as short-term. As a preventive measure quinidine was administered orally to 18 patients (0.8–1.2 g daily). Of these, 6 presented renewed atrial fibrillation after 1 month and 2 others within 6 months. Of the 6 patients who did not receive quinidine (quinidine hypersensitivity in 2 cases; irregular intake in 1 case; other reasons in 3 cases), 3 presented atrial fibrillation within 1 month, 1 after 6 months, and 1 other after 11 months. Results *in toto* thus amounted to long term in 12 cases and to short term in the remaining 12 (cf. Fig. 1).

Results

Of 24 patients presenting with sinus rhythm both immediately and 24 hours after cardioversion, 1 showed no mechanical function in either atrium, while in 2 others such function was absent in one atrium only (left and right, respectively). The relative amplitude of the a wave ranged from 1 to 53 per cent. In about half of the total number examined, the amplitude exceeded 15 per cent, the upper limit of the normal value (Bertrab and Mahlich, 1968).

Patients maintaining long-term sinus rhythm had a higher a wave immediately and 24 hours after cardioversion than those with a short-term result. This correlation is especially significant for the left-sided a wave, though there is a great variability in the values and overlapping in the 2 groups (Table). The mean values of the patients with long-term result show only a slight decrease from that immediately after cardioversion to 24 hours later (mean change left-sided a wave 1.66%, right-sided a wave 2.33%, respectively), whereas the remainder decreased to a greater extent (4.5% and 3.97%, respectively).

The modification of the a wave was studied in more detail by calculating the mean value from all recording points. The change then was expressed as a percentage of the original (i.e. immediately post-cardioversion) value. A modification, representing ± 15 per cent, was assumed to be unchanged because

FIG. 2 The alteration of the amplitude of the a wave during the first 24 hours after cardioversion. Above patients with long-term, below patients with short-term results in sinus rhythm. Because of the accepted margin of error an alteration of ± 15 per cent is assumed to mean no change.

TABLE A wave and sinus rhythm after conversion

		Long-term result 12 patients	Short-term result 12 patients	Student t test*
Left-sided a wave (%)	Immediately after cardioversion	19.83 ± 16.6	13.33 ± 10.8	P < 0.15
	24 hours later	18.17 ± 11.4 Δ1.66	8.83 ± 4.1 Δ4.5	P < 0.01
Right-sided a wave (%)	Immediately after cardioversion	23.33 ± 13.6	18.42 ± 10.9	P < 0.2
	24 hours later	21.00 ± 11.2 Δ2.33	14.45 ± 5.4 Δ3.97	P < 0.05

* Mean values.

of the accepted margin of error (see Fig. 2). Only 4 of 12 patients with a long-term result showed a decrease of more than 25 per cent. On the other hand, a majority of the patients with short-term result showed a decrease.

In summary, it seems that the presence of a raised a wave immediately after cardioversion and again 24 hours later is a good omen for a long-term result, while a low or non-existent a wave suggests that the sinus rhythm will not last for long. A decrease in the a wave during the first 24 hours likewise suggests short-term results. On the other hand, a sharp rise in the a wave during this period gives no indication that the sinus rhythm will be maintained.

Discussion

The a wave observed in the kinetocardiogram in the presence of sinus rhythm can easily be correlated with the P wave of the electrocardiogram. It follows the P wave with a certain time lag which, depending on the side of the heart which is being recorded, exactly corresponds to the electromechanical time interval. The amplitude of the a wave is directly related to the contraction of the atrium in question. Thus, where the atrium is overloaded, the a wave will be high; on the other hand, where sinus rhythm is absent, as in atrial fibrillation, no a wave will be observed. The kinetocardiogram thus provides a simple and reliable method of establishing the presence or absence of atrial contractions.

The present study shows that in the presence of sinus rhythm following cardioversion absence of atrial contractions is rare. Of 24 patients examined immediately after cardioversion, only 1 failed to show contraction of either atrium; 24 hours later there was still no mechanical function. Another patient showed absence of contraction of the right atrium immediately after cardioversion; but contraction became evident 24 hours later. A third

patient showed no contraction of the left atrium at the end of the first 24 hours. The percentage of cases in which atrial contractions failed to appear was thus about 8 per cent. These figures contrast sharply with those of a similar investigation carried out by means of heart catheterization (Logan *et al.*, 1965). In this study 3 out of 5 patients showed no function of one or both atria. This represents an incidence of some 60 per cent. This wide discrepancy can perhaps be explained by the differing degrees of cardiocirculatory disorder in the respective groups. The patients in the study mentioned all had severe left heart disease. In fact the one patient in the present series, who showed no contractions of either atrium, had an atrial septal defect with large left-to-right shunt.

In 217 cardioversions we have never seen pulmonary oedema – in contrast to Resnekov and McDonald (1965) who, in 140 cases of cardioversion performed for various types of arrhythmia, observed pulmonary oedema in 3 instances. Since the atrial contraction itself was not studied in these cases, it is impossible to determine whether or not the pulmonary oedema in fact resulted from a non-functioning left with a normally contracting right atrium.

In comparing the amplitude of the a wave with the duration of the established sinus rhythm, one is struck by the fact that patients with a high a wave often remain in sinus rhythm for longer periods than those in whom the a wave is low or even absent. This applies to the left-sided a wave in particular. A diminution of the amplitude of a wave of more than 25 per cent may likewise be taken as indicating that sinus rhythm will not last for long. By contrast, an increase of the a wave does not seem to indicate a better result than an unchanged a wave. This is hard to explain, especially when one considers that normal subjects also present low a waves, while patients with severe cardiocirculatory disorders often present very high a waves. One may, therefore, as-

sume that, after a long period of overload, the atrium, once the contractions are restored, is not immediately able to adapt itself to normal conditions. A raised a wave thus indicates the presence of powerful contractions and suggests a favourable long-term prognosis. By contrast, a low a wave, dropping rapidly during the first 24 hours, or the absence of any wave at all, must arouse suspicions that the contractions are insufficient and that the atrial fibrillation is likely to recur before long.

From all this it is clear that, in the presence of sinus rhythm following cardioversion performed to eliminate atrial fibrillation, the kinetocardiogram not only confirms the presence of atrial contractions as such, but also renders possible a further evaluation of the latter, providing information about how long the sinus rhythm will last.

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