Electric Alternans in Pericardial Effusion

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Evidence is presented which indicates that electric alternation is frequently associated with pericardial effusion; that this alternation is of a unique type; and that it is caused by movement of the heart in the fluid filled pericardial sac.

In 1946 one of us observed and reported\(^1\) a case of pericardial effusion with simultaneous electric alternans of the auricles and ventricles and in the following year noticed a publication illustrating the same electric phenomenon in a similar case\(^2\) (see fig. 1A and B).

Some time later the other author of this paper (E. B.) while studying a series of cases of pericarditis with effusion remarked on the occurrence both of alternans and of less regular non-respiratory fluctuations in amplitude of the ventricular complexes and postulated that they arose from the free movement of the heart suspended in fluid.\(^3\) Observations made at that time and more recently, together with a scrutiny of the cases reported in the literature, has led us to conclude, first, that there is an association between electric alternans and effusion which is more than fortuitous and second, that there are some unique features of the alternans which is found in cases of effusion.

Finally it has led us to suggest a mechanism for the electric alternation in these cases which supposes the free movement of the heart in the fluid filled pericardial sac.

Electric alternation of the ventricular complexes can be divided into three main groups; a group associated with very rapid

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Fig. 1. A. Simultaneous alternation of auricular and ventricular complexes.\(^1\) Lead CR4. B. Simultaneous alternation of auricular and ventricular complexes.\(^2\) Lead II. C. Fluctuation of voltage during respiratory arrest. Lead V1.

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TABLE 1.—The Probable Diagnosis in 27 Published Cases of Ventricular Alternans

<table>
<thead>
<tr>
<th>Author</th>
<th>Case</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traut\textsuperscript{12}</td>
<td>1</td>
<td>Acute pericard. with effusion</td>
</tr>
<tr>
<td>Wood\textsuperscript{17}</td>
<td>1*</td>
<td>Pericard. malignancy</td>
</tr>
<tr>
<td>Risinger et al.\textsuperscript{16}</td>
<td>1*</td>
<td>Malignant hemopericard.</td>
</tr>
<tr>
<td>Fletcher\textsuperscript{2}</td>
<td>1*</td>
<td>Malignant pericard. effusion</td>
</tr>
<tr>
<td>McGregor\textsuperscript{1}</td>
<td>1*</td>
<td>Tuberc. pericard. effusion</td>
</tr>
<tr>
<td>Feldman\textsuperscript{20}</td>
<td>1</td>
<td>Malignant hemopericard.</td>
</tr>
<tr>
<td>Hamburger et al.\textsuperscript{7}</td>
<td>1</td>
<td>Ischemia</td>
</tr>
<tr>
<td>Brody\textsuperscript{15}</td>
<td>1</td>
<td>Hypertension</td>
</tr>
<tr>
<td>Kalter, Schwartz\textsuperscript{6}</td>
<td>1</td>
<td>Acute pericard. Probable effusion</td>
</tr>
<tr>
<td>Kalter, Grishman\textsuperscript{1}</td>
<td>7</td>
<td>Syphilitic Miliary tuberc.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Ischemia. Congest. fail.</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Unknown</td>
</tr>
<tr>
<td></td>
<td>11*</td>
<td>Suppurative pericard. effusion</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Rheumatic pericard. Congest. fail.</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Ischemia ? Pericard.?</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Rheumatic heart dis. Pulmon., embolism</td>
</tr>
<tr>
<td>Groedel, Miller\textsuperscript{18}</td>
<td>16</td>
<td>Hypertensive. Ischemia</td>
</tr>
<tr>
<td>Groedel, Thompson\textsuperscript{12}</td>
<td>1</td>
<td>During pneumonectomy</td>
</tr>
<tr>
<td>Missal, Crain\textsuperscript{14}</td>
<td>1</td>
<td>Idiopathie</td>
</tr>
<tr>
<td>Levine\textsuperscript{19}</td>
<td>1</td>
<td>Hypertension. Ischemia</td>
</tr>
</tbody>
</table>

* Simultaneous alternation of P waves.

heart rates; a group exhibiting intraventricular conduction disturbances; and a group exhibiting alternation of apparently normal complexes at normal or only moderately increased heart rates. It is the third type which is sometimes associated with pericardial effusion and with which we are concerned here.

Evidence that there is an association between alternation and pericardial effusion depends mainly on an analysis of all the electrocardiographic records of alternans of this type, published with clinical data, available to us in the literature. Portions of the electrocardiograms of 26 cases were available for study. Of these, nine cases or one third are clearly associated with pericardial effusion, in a further two effusion seems likely (reference 4, cases 13 and 14), and in several others it cannot be excluded on the information supplied (table 1). The suggestion that there is an association between electrical alternans and effusion receives further support from Harvey and Whitehill\textsuperscript{3} who in reviewing the electrocardiograms of 15 cases of tuberculous pericardial effusion remarked that "alternation in amplitude (of the ventricular complex) was occasionally observed as was change in the form of each second or third complex. These changes were usually present only in the cases with fairly large effusions". In an attempt to determine the frequency of electrical alternation in subjects with effusion, a series of 58 proven cases was reviewed. (Derived from the records of three Johannesburg hospitals together with cases seen personally by the authors.) Eight cases exhibited either permanent or transient alternation of the ventricular complex.

The conclusion that the alternans of pericardial effusion is unlike other types of alternans rests on several points. First, review of all the tracings of ventricular alternation which are available to us revealed simultaneous alternation of the P wave in three of our own cases and in six published records (table 1). In all but one\textsuperscript{4} in which there were no data supplied there was an associated pericardial effusion. It is of interest that in only two\textsuperscript{1,16} of the instances cited in the literature had the P wave alternation been reported by the respective authors. To demonstrate this alternation it was sometimes necessary to enlarge these tracings from the size in which they had been printed, but when this was done the P wave alternation was usually clearly visible (fig. IA and B). Though by no means proved, it seems possible that simultaneous alternation of auricular and ventricular complexes may be confined to cases of pericardial effusion.

Another unusual feature of these cases is the manner in which a regular alternans may
change in a few beats to a fluctuation of voltage resembling marked respiratory variation as reported by Harvey and Whitehill. In two of our cases, however, these changes were evident despite complete respiratory arrest. In one case (fig. 2) there are apparently two rhythms affecting the ventricular complex. One causes every second beat to be larger than its predecessor and the other causes every fourth beat to be especially large. In the other (fig. 1C) a slow waxing and waning of voltage is evident. There is insufficient evidence on which to decide whether these phenomena are unique to alternation associated with pericardial effusion. They are, however, a striking feature of some cases and we have observed nothing similar in records of alternation when not associated with effusion.

A third unusual feature of electrical alternans with pericardial effusion was the observation in
one case of alternation of heart sounds in the absence of alternation of the pulse. As the implications are of some importance the case will be discussed in some detail.

Case A. T., a female aged 42 years, had an infiltrative lung lesion and all the features of a large pericardial effusion with slight tamponade. The electrocardiogram showed a regular electrical alternans best seen in lead V5 (fig. 3). This alternans frequently disappeared, but could always be reproduced by slight exercise such as rising once or twice to the sitting position. Once initiated it was unaffected by posture (supine, left lateral, sitting upright, sitting forward) or by respiration. Pulsus alternans could at no time be detected clinically or with a sphygmomanometer, but alternation of intensity of heart sounds could be easily heard with a stethoscope and was recorded phonocardiographically (fig. 4). Intra-arterial pressures were recorded during respiration and during voluntary apnoea (fig. 5), and although a well marked pulsus paradoxus was present during respiration, the tracing showed no fluctuation while breath was held. A supine ballistocardiogram was too disordered to be of much significance, but gave no evidence of mechanical alternans. An electrocardiogram recorded during paracentesis showed that the alternans disappeared after the removal of about 200 ml. of pericardial fluid and it has not been possible to reinduce it since.

It was concluded that, excluding isolated mechanical alternans of the right ventricle (a possibility which could not be tested in so ill a patient) movement of the heart relative to the stethoscope with alternate beats was the most likely explanation for the variation in heart sounds.

**DISCUSSION**

Alteration of the ventricular complex is not a common phenomenon. Hamburger and co-workers had seen only one example in a series of 10,000 electrocardiograms and Kalter and Schwartz reported an incidence of 1 per 1,212 patients, though as these authors suggested it is probable that more cases will be found if careful scrutiny is made particularly of multiple chest leads. Although the number of tracings of alternans we were able to examine was small, the incidence of pericardial effusion in at least one third, and possibly more, must be considered significant. Neither alternans nor the respiratory-like fluctuations of voltage reported above have been seen by us in cases of pericarditis in the absence of effusion and it would appear that the effusion and the type of alternans under discussion must be etiologically connected. In addition the fact that these patterns were found on eight occasions in a review of electrocardiograms from 38 of our own cases of effusion indicates that they have obvious diagnostic value.

Isolated alternation of the auricular complex,
though not uncommon in animal experiments, is extremely rare in the human. We could find only one authentic example in the available literature. Most authorities make no mention of it while an example shown by Katz appears actually to be a case of alternate auricular premature beats. The occurrence of simultaneous alternation of auricular and ventricular complexes is a finding, therefore, which can hardly be fortuitous. Any hypothesis put forward to explain this association should also explain the fact that simultaneous alternation of auricular and ventricular complexes is an observation apparently confined to cases of pericardial effusion. It should also offer an explanation for the simultaneous alternation of the ventricular complexes and heart sounds in the absence of pulsus alternans observed in case A. T.

Previous theories of the mechanism of alternation could clearly not meet all these demands. The suggestion originally made by Baskind that the phenomenon of electrical alternation in these cases might be the result of free movement of the heart in the pericardial sac would, however, be consistent with the observed facts.

On consideration it does not seem unlikely that the heart suspended in a large sac of fluid should move more than the normal organ. In view of the spiral arrangement of the great vessels as they leave the heart a periodic fluctuation in their tension might well produce a rotatory effect on the “floating” organ. The extent of movement would depend on the natural period of oscillation of the heart thus suspended, on its rate of contraction, and

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**Fig. 4.** Case A. T. Low frequency heart sound tracing above, with synchronous lead V½ below. There is alternation of both the first and second heart sounds.

**Fig. 5.** Continuous recording of electrocardiographic lead V½ (above), brachial arterial pressures (middle) and pneumogram (below). Note the complete absence of alternans best seen during apnoea.
possibly also on the presence of additional stimuli, such as respiration. In the majority of cases no apparent movement at all takes place. In others, however, a rotatory oscillation could be set up bearing a 1:2 relation with the heart beat which would remain fairly constant for long periods. In other cases a less regular oscillation might be set up bearing 1:2 or a 1:3 relationship with the heart beat. Respiration might well play a bigger part in the initiation of these slower movements, but as has been shown they may persist after respiration has been arrested.

Such an hypothesis would adequately explain the following observations:
(a) The obvious association between pericardial effusion and electrical alternans.
(b) The fluctuations in voltage other than true alternans found in some cases with pericardial effusion.
(c) Synchronous alternation of auricular and ventricular complexes, a result to be expected if the alternation were due to movement of the whole heart.
(d) Alternation of intensity of heart sounds in the absence of manometric or ballistocardiographic evidence of mechanical alternation. This, in terms of the present hypothesis would be the effect of cardiac movement bringing the heart valves closer to the chest wall with alternate beats.

Clearly this explanation of electrical alternans could apply only to cases of pericardial effusion. There remain those cases in which there is an obvious alternating disturbance of conduction, those cases associated with paroxysmal tachycardia and those cases without pericardial effusion which show electrical alternans at normal rates, with apparently normal conduction. In these cases the well known theoretical explanations are clearly tenable.¹⁰,¹¹

**Summary and Conclusions**

Evidence is produced that electrical alternans or a less regular fluctuation of voltage not due to respiration is sufficiently common to be of diagnostic value in pericardial effusion.

Simultaneous alternation of auricular and ventricular complexes has so far only been observed in cases with pericardial effusion and this association would appear to be unique.

It is suggested that the explanation for the fluctuations in voltage (regular or irregular) sometimes observed in cases of pericardial effusion is due to movement of the heart within the fluid filled pericardial sac, and some evidence is produced in support of this hypothesis.

**Summario e Conclusiones in Interlingua**

Es presentate datos demonstrante que alternantia electrica (o voltofluctuaciones minus regular) que non es causate per respiration occurre satis frequentemente pro esser de valor diagnostic in effusion pericardiac.

Alternation simultanea in le complexos auricular e ventricular ha usque nunc essite observate exclusivemente in casos con effusion pericardiac. Il pare que iste association es specific.

Nos submitte le these que le voltofluctuaciones (tanto regular como etiam irregular) que se observa a vices in casos de effusion pericardiac es causate per le movimento del corde in le fluido intra le sacco pericardiac. Alicant datos que corrobora nostre theses es presentate.

**Acknowledgments**

Our thanks are due to those physicians who have kindly allowed us to see their cases and to Professor G. A. Elliott and Doctor B. van Lingen for their assistance to us in writing this paper.

**REFERENCES**


9 Kisch, B.: Der Herzalternans. Dresden, T. Steinkopff, 1932. (Quoted from Kisch[10].)


