Case Reports

Artificial Pacemaker-Induced True vs. Pseudo-Electrical Alternans

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SUMMARY

A unique case of heretofore undescribed 2:1 ventricular electrical alternans in the presence of artificial pacemaker-induced ventricular rhythm is presented. Three instances of 2:1 ventricular pseudo-electrical alternans due to ventricular fusion bigeminy in patients with permanent demand pacemakers are also discussed.

Additional Indexing Words:

Arrhythmias related to artificial pacemaker   Electrical alternans
Fusion beats   Ventricular bigeminy

WITH wide use of artificial pacemakers, increasing numbers of artificial pacemaker-induced or related arrhythmias have been reported. Extensive reviews of this subject have recently been published by Castellanos and his associates¹⁾ and by Kastor and Leinbach.²⁾ The purpose of the present communication is to present a unique case of heretofore undescribed ventricular electrical alternans which occurred in the presence of artificial pacemaker-induced ventricular rhythm. Three cases of ventricular pseudo-electrical alternans due to ventricular fusion bigeminy between natural sinus and artificial pacemaker-induced beats are also discussed.

CASE REPORTS

Case 1. A 61-year-old man developed a series of tachyarrhythmias including sinus tachycardia, atrial flutter, runs of ventricular premature contractions, ventricular tachycardia and fibrillation during the first week of acute myocardial infarction. All except for ventricular tachycardia and fibrillation were controlled by

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digitalis, quinidine, lidocaine, propranolol hydrochloride, and direct current shock. Because of refractory ventricular tachycardia and fibrillation, a fixed-rate transvenous catheter pacemaker was inserted into the right ventricle. Following insertion of the pacemaker (pacer rate: 115 per min.) the ventricular tachyarrhythmia was suppressed. However, the electrocardiogram taken at this time showed 2:1 true ventricular electrical alternans. There was no evidence of pericardial effusion.

Case 2. An 82-year-old man was admitted to the hospital with a chief complaint of dizziness of 2 weeks' duration. A permanent demand pacemaker (Medtronic 5841) was implanted with a preset rate of 60 per min. for Adams-Stokes syndrome due to complete atrioventricular (A-V) block 20 months previously. An admission electrocardiogram showed artificial pacemaker-induced ventricular *pseudo*-electrical alternans.

Case 3. An 84-year-old man who had installation of a permanent demand pacemaker (Medtronic 5841) 19 months previously for symptomatic complete A-V block was brought to the hospital because of a slowing of pulse rate. The preset pacemaker rate was 60 per min. Admission electrocardiogram showed artificial pacemaker-induced ventricular *pseudo*-electrical alternans.

Case 4. A 78-year-old man who had implantation of a permanent demand pacemaker (Medtronic 5841) 10 months previously came to the Cardiac Clinic for follow-up care. The preset pacer rate was 60 per min. Electrocardiogram taken at this time showed artificial pacemaker-induced ventricular *pseudo*-electrical alternans.

ANALYSIS OF ELECTROCARDIOGRAMS

Electrocardiogram of Case 1 (Fig. 1) shows artificial pacemaker-induced ventricular rhythm (fixed-rate pacer: 115/min.) with consecutive atrial capture. The configuration of the QRS complexes alter on every other beats indicating *true* 2:1

Fig. 1. Two to one ventricular electrical alternans with consecutive atrial capture in artificial pacemaker-induced ventricular rhythm (rate: 115/min.) (Courtesy of Dr. Irving L. Rosen).

ventricular electrical alternans.

In Fig. 2 (Case 2), leads II-b and -c are continuous. Lead II-a shows sinus rhythm (atrial rate: 75/min.) with artificial pacemaker-induced (demand unit) ventricular rhythm. A slowing of the pacemaker discharge (rate: 39/min.) indicates a malfunction of the unit. Leads II-b and c showed 2:1 ventricular *pseudo*-electrical alternans due to ventricular fusion (between sinus and demand pacemaker beats) bigeminy in the presence of 2:1 A-V block. It is interesting to observe that a pre-fusion interval (the interval from fusion beat to preceding natural beat) is shorter (1.44 sec.) than ordinary pacemaker interval (1.54 sec.).

In Fig. 3 (Case 3), leads II-a and b are continuous. This tracing shows artificial pacemaker-induced (demand unit) ventricular rhythm with a rate of 51 per min. and intermittent appearance of patient's own natural beats (marked O) alternating with ventricular fusion beats (marked X) between natural and pacemaker beats. Slowing of the pacemaker impulse discharge, needless to say, represents a malfunction of the unit. The origin of the P wave in this case is uncertain. However, it is thought to be of sinus origin, for left axis deviation of the P wave is not uncommon among elderly individuals with advanced heart disease.⁷⁾ Because of alternating appearance of natural and ventricular fusion beats, 2:1 ventricular *pseudo*-electrical alternans is produced. As seen in Case 2, the pre-fusion interval is shorter (1.14 sec.) than ordinary pacemaker interval (1.16 sec.).

In Fig. 4 (Case 4), leads II-a and b are continuous. This record reveals 2

Fig. 2. Artificial pacemaker-induced 2:1 ventricular *pseudo*-electrical alternans. S indicates sinus beat whereas X indicates ventricular fusion beat. (The numbers in this and subsequent figures represent hundredths of a second.)

Fig. 3. Artificial pacemaker-induced 2:1 ventricular *pseudo*-electrical alternans. Natural beat is indicated by O whereas ventricular fusion beat is indicated by X.

Fig. 4. Artificial pacemaker-induced 2:1 ventricular pseudo-electrical alternans. S indicates sinus beat whereas X represents ventricular fusion beat.

artificial pacemaker-induced (demand unit) ventricular beats followed by 2:1 ventricular *pseudo*-electrical alternans due to sinus beats (marked S) alternating with ventricular fusion beats (marked X). Slowing of the artificial pacemaker discharge (rate: 54/min.) indicates a malfunction of the unit. As observed in Cases 2 and 3, the pre-fusion interval is shorter (0.94 sec.) than the ordinary pacemaker interval (1.08 sec.).

DISCUSSION

Case 1 fulfilled the conventional criteria of ventricular electrical alternans.^{4), 5)} Namely, alternation in configuration of QRS complexes occurs with regular rhythmicity (2:1 ratio) and constant R-R intervals. It is evident that the QRS complexes are originating from 1 pacemaker (artificial) and have no relation to respiration. The unique feature is that the electrical alternans in this case developed in artificial pacemaker-induced ventricular rhythm. To our knowledge, this is the first such electrocardiographic finding reported. Electrical alternans can involve P, QRS, or T complexes, or any combination of these. However, the most common form of electrical alternans involves QRS complexes alone and among this group, a 2:1 electrical alternans is the commonest alternating ratio⁵⁾ as observed in Case 1. The exact mechanism of electrical alternans is not yet clearly understood. It would appear unlikely that the electrical alternans in this case is due to alternating power of the pulse generator discharge since the amplitude of pacer spikes is constant throughout. Alternating abnormal prolongation of the refractory period of the ventricular myocardium is most likely responsible for the production of electrical alternans in this patient with acute myocardial infarction associated with congestive heart failure.⁵⁾

The same criteria fulfilled in Case 1 are also observed in Cases 2, 3, and 4, with the critical exception in that the alternating QRS complexes are originating from 2 different pacemakers, namely natural and artificial, rather than one. The equal or nearly equal rate of the natural and artificial pacemakers pro-

Table I. Various Cycle Lengths in 3 Patients Manifesting Ventricular Pseudo-electrical Alternans

	Case 2	Case 3	Case 4
Pre-set Pacer Interval	100* (60)**	100* (60)**	100* (60)**
Actual Pacer Interval	154* (39)**	116* (51)**	108* (54)**
Pre-Fusion Interval	144* (41)**	114* (53)**	94* (64)**
Post-Fusion Interval	146* (41)**	114* (53)**	98* (61)**

* The numbers in this table represent hundredths of a second.

** The numbers in the parenthesis represent corresponding rate.

vided the chance to produce ventricular fusion beats in bigeminal form. The pre-fusion interval (distance from the fusion beat to the preceding natural beat) and the post-fusion interval (distance from the fusion beat to the following natural beat) are very similar, as shown in Table I. For these reasons, the term "*pseudo-electrical alternans*" has been chosen to describe alternating configuration of QRS complexes in Cases 2, 3, and 4, and it is felt to be appropriate for this paper. A similar case was previously reported by Spritzer and associates⁶⁾ who used the term "escape-capture bigeminy". The identical electrocardiographic finding occurring in natural rhythm without an artificial pacemaker, was also recently reported by the present authors.⁷⁾ In that case, sinus beats alternated with ventricular fusion beats (between sinus and ventricular ectopic beats) masquerading as 2:1 ventricular electrical alternans.⁷⁾ It is obvious from Table I that Cases 2, 3, and 4 had pacemaker malfunction, evidenced by a significant slowing (between 39 and 54 per min.) of the pacer rate (pacemaker bradycardia), in comparison with the preset rate of 60 per min. The units have been replaced in these patients. In addition, it is noteworthy that the pre-fusion interval is considerably shorter than the interval between 2 consecutive pacemaker artifacts (pacer interval) in all 3 patients with *pseudo-electrical alternans* (Table I). This difference in the discharge rate of the demand pacemaker is considered to be due to change in intraventricular conduction and/or difference in QRS configuration.^{6), 8)} Therefore, it would seem that one cannot determine the preset rate of the pacemaker from a routine ECG tracing if *pseudo-electrical alternans* persists without a period consecutively appearing artificial pacemaker beats. The significance of this *pseudo-electrical alternans* cannot be determined from the few cases herein presented, though it may be significant in that all of them had pacemaker malfunction.

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