Concomitant pulsus and pseudoelectrical alternans in severe systolic dysfunction

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Introduction

Pulsus alternans and electrical alternans are important and useful clinical signs, indicating several conditions of cardiac dysfunction. Pulsus alternans is associated with severe systolic dysfunction, which is involved in calcium overload and impaired calcium cycling. To date, the proposed mechanisms of pulsus alternans include the alternative change in left ventricular end-diastolic pressure and stroke volume mediated by Frank-Starling law, as well as alternation of calcium transient coupling to myocardial contractility. On the other hand, electrical alternans is usually caused by massive pericardial effusion owing to cardiac motion, and occasionally found in sustained tachycardia due to alternans of conduction or refractoriness. Regarding to heart failure, T wave alternans has been well studied, whereas QRS alternans was less discussed. Here we demonstrated a case with both of these phenomena, which may share a common underlying mechanism, such as impaired calcium release and reuptake resulting in rhythmic variation of calcium transient.

Case report

A 41-year-old man complained of progressive dyspnea on exertion for 6 months. At presentation, tachycardia with S3 gallop was noted, along with bilateral basal crackles in chest auscultation, implying the condition of heart failure. During blood pressure measurement, Korotkoff sounds were heard with the rate of 60 beats per minute when the cuff pressure was fixed at 140 mm Hg, while the rate doubled at 130 mm Hg, suggesting pulsus alternans with pressure gap of 10 mm Hg. Echocardiography revealed left ventricular ejection...
fraction around 10%, as well as the rhythmic variation of the peak flow velocity at the ascending aorta (Figure 1), indicating the alternative change of stroke volume. Electrocardiography showed a beat-to-beat shift in the QRS axis and amplitude (Figure 2). Typically, electrical alternans was seen in patients with massive pericardial effusion owing to cardiac motion, but there was no effusion in this case. Therefore, this case is better described as “pseudoelectrical alternans,” which is the phenomenon where beat-to-beat variation in axis or amplitude is due to alternation in conduction rather than excessive cardiac motion, and may occur in severe systolic dysfunction.

Discussion

The pathophysiology of pulsus alternans in systolic dysfunction is attributed to 2 major mechanisms: Frank-Starling relationship and impaired calcium cycling. According to the former theory, congestive heart failure with elevated end-diastolic pressure generates higher myocardial contractility, which empties more effectively and lowers the end-diastolic pressure in the same cardiac cycle; the contractility of the next cycle then becomes weaker, thus the end-diastolic pressure re-elevates again and the cyclic beat-to-beat alternation is maintained. The theory of impaired calcium cycling is composed by the positive relationship between the end-diastolic calcium content in sarcoplasmic reticulum and its release, along with spontaneous calcium leak from sarcoplasmic reticulum and reduced calcium reuptake in heart failure, all of which contribute to the alternative change in cytosolic calcium concentration and its coupling to membrane voltage as well as contractility.1

Regarding electrical alternans, it includes the alternans in QRS-T amplitude and QT interval, and the microvolt T-wave alternans provided an accurate means to predict ventricular tachyarrhythmias and sudden cardiac death in patients with systolic heart failure.2 QRS alternans is mostly caused by massive pericardial effusion owing to cardiac motion, and sometimes develops in supraventricular tachycardia because of the intermittent refractoriness of the conduction system.3 The latter, involving alternans in conduction, is called “pseudoelectrical alternans,” which was first described by Klein et al4 regarding a case with procainamide-induced left anterior hemiblock of the 2:1 type.

The beat-to-beat alternation of cytosolic calcium regulation is an important reason for both mechanical and pseudoelectrical alternans,5 and the concomitant existence in

Figure 2  Electrical alternans. The QRS axis and amplitude varied alternatively, along with a premature ventricular complex.
this case implied the major contribution of impaired calcium cycling in the underlying mechanisms of both phenomena.

References

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