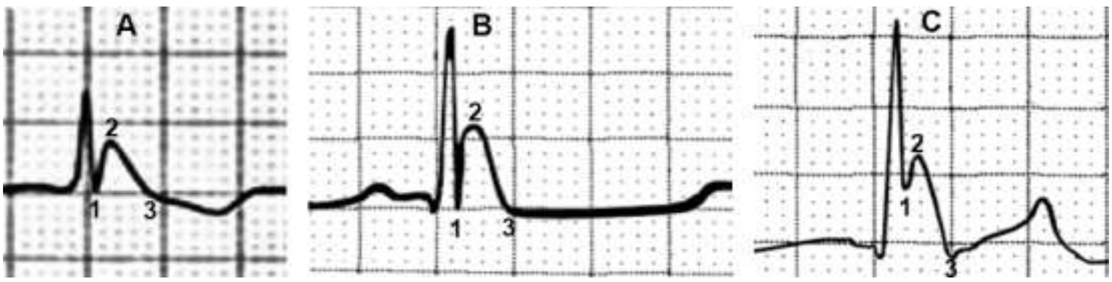
The J wave variants and their mysteries

The J wave is an inconstant physiological or pathological deflection of the ECG wave observed in hypothermic and normothermic settings, such as channelopathies (Brugada syndrome, early repolarization syndrome, idiopathic ventricular fibrillation, congenital short QT syndrome Brugada phenocopies, severe hypercalcemia, subarachnoid hemorrhage, dysfunction of the cervical sympathetic system, after cardiac arrest, concealed forms of arrhythmogenic cardiomyopathy, acute myocardial infarction, Prinzmetal angina). It is registered in the final portion of the QRS complex and the beginning of the ST segment (J point) coincident with phase 1 of monophasic action potential. The letter J means "junction", that is, approximately the junction point of the end of the QRS complex with the beginning of the ST segment (Barnes, 1943). The duration of overlap between the onset of ventricular repolarization and the end of the QRS duration determined from isopotential maps has a range from 4 to 16 ms (Mirvis 1982). J wave occurs in the descending ramp of the R-wave form either a notching followed by a dome or hump (camel hump sign) (Abbott 1976) morphology immediately after the QRS complex or a smooth transition from the QRS complex to the ST segment " slurring". Figures 1 and 2 show the 2 variants of the J wave integrating the early repolarization pattern.

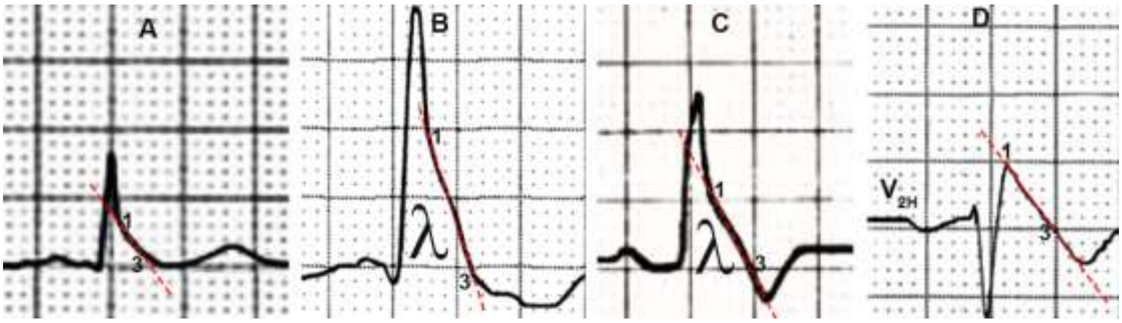
Figure 1 J wave notching



1: J-onset; 2: J-peak (Jp); 3: J-termination (Macfarlane 2015).

A: With negative asymmetrical T wave; B: Without visible T wave; C: Positive asymmetrical T wave.

Figure 2 J wave slurring, lambda or "Gussak wave" (Gussak 2004)



In this variant we have only two points: 1 (J-onset) and 3 (J-termination).

A: With positive T wave; B: With negative ST and T wave; C: With negative symmetrical T wave; D: With negative symmetrical T wave only in right precordial leads: type 1 Brugada ECG pattern.

Effect of ECG filter settings on J-waves

Nekagawa et al. performed a systematic study on the association between ECG filter settings and the J-wave morphology. The incidence of J-waves was significantly different among different low-pass filter settings. J-waves appeared more frequently with higher cutoff of low-pass filters (150- and 100-Hz) while at a cutoff of 25- or 35 Hz the J-waves were attenuated or eliminated. The amplitude of the J-waves was compared at all filter settings in patients with notch-type J-waves because the J-wave amplitude can be determined more correctly in notch than slur-type J-waves. The amplitude of J-waves was significantly lower with 25- and 35-Hz filters than 75-, 100-, and 150-Hz filters. The apex of the notch was duller and the amplitude was decreased when low cutoff low-pass filters were applied, which resulted in the disappearance of the J-waves.

They evaluated the incidence of J-waves using different low-pass filters. When we considered both notching and slurring as J-waves, their incidence decreased from 16.8% with 150-Hz to 9.5% with 25-Hz filtering. The incidence of notch-type J-waves decreased from 10.7% with 150-Hz to 3.2% with 25-Hz filtering. Low-pass filters with low cutoff frequencies may hide clinically important signals such as J waves and affect the diagnosis. In addition, the J-waves of the shorter duration more frequently disappeared with the low cutoff of low-pass filter settings.

J-waves are usually defined as notching or slurring with an amplitude greater than 0.1 mV at the terminal QRS complex (Haïssaguerre 2008). Their reported incidence ranged widely from 5% to 24% (Haïssaguerre 2008; Rosso 2008; Tikkanen 2009; Haruta 2011). This may reflect age-, sex-, and race differences in the earlier study populations and differences in the definition of J-waves. Our findings suggest that the ECG filter setting is an important consideration in attempts to understand differences in the reported incidence of J-waves. ECG filtering is important for the interpretation and comparison of ECG signals. As low-pass filters allow the passage of low-frequency bioelectric signals but attenuate high-frequency signals such as muscle noise (Kligfield 2007a; García-Niebla 2009a), the latter must be filtered adequately without the loss of clinically important information. The 2007 guidelines of the AHA recommended a standard low-pass filter of 150 Hz for adolescents and adults and 250 Hz for children (Kligfield 2007a). The inappropriate application of low-pass filters with a low cutoff eliminates most of the muscle noise but also attenuates or eliminates the high frequency component in the ECG signals such as the R-wave voltage, the notch within the QRS complex, and spikes elicited by pacemakers (Kligfield 2007b; García-Niebla 2009a,b; García-Niebla 2010). Current ECG recorders allow changes in the high- and low-pass filter settings. Kligfield and Okin (Kligfield 2007b) reported that the ECG filter settings were inappropriate in 75% of ECGs obtained within a single American medical community. García-Niebla et al. (García-Niebla 2010) who showed that QRS notching, clearly present with lowpass filters at 150- and 100 Hz, changed to slurring at 40 Hz in a patient manifesting J-waves, cautioned to use an appropriate ECG filter setting.

Their study has some limitations. The background of our study population varied and we included patients with organic heart disease. The mechanisms underlying the genesis of J-waves recorded in patients with organic heart diseases, for example in patients in the acute phase of myocardial infarction (Naruse 2012; Tikkanen 2012) may be different in healthy populations. However, our patients with coronary artery diseases were in the stable chronic phase of previous myocardial infarction or angina pectoris. In addition, in the sole patient with idiopathic ventricular fibrillation the J-wave changes seen at the different filter settings were similar to those seen in the other patients. Studies are underway to confirm the relevance of our findings for the manifestation of J-waves in patients with idiopathic ventricular fibrillation (Nakagawa 2014).

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