Human Left Ventricular Wall Vibration Responded to Precordial Minute Vibration

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KOIWA, Y., KIKUCHI, J., TAKAGI, T., HONDA, H., HOSHI, N. and TAKISHIMA, T. Human Left Ventricular Wall Vibration Responded to Precordial Minute Vibration. Tohoku J. Exp. Med., 1989, 159 (1), 79-80 — We examined, noninvasively, the response of the left ventricular (LV) wall to precordially applied vibration in seven normal subjects. The LV posterobasal wall vibration was detected by an esophageal vibration sensor. Even though the amplitude of input vibration was maintained at a constant level, a sharp change in amplitude of the LV wall vibration was observed during the cardiac cycle, especially when 1) the subject was lying in a 45° left anterior oblique supine position, 2) the sensor was positioned at approx. 40 cm from the incisor teeth and 3) breath was at expiration. The pattern of this amplitude modulation changed with the input frequency. We concluded that the change in amplitude of output signal must have resulted from LV contraction and relaxation.

When sinusoidal vibration was applied directly to the anterior epicardium in isolated canine left ventricle (LV), the output signal from the contralateral portion of the LV showed an amplitude modulation with the cardiac contraction (Koiwa et al. 1986). Analyzing these signals, we could draw an instantaneous LV transfer function curve (TFC), which was well correlated to ventricular physical properties and its myocardial heterogeneity such as regional myocardial ischemia (Hashiguchi et al. 1988). If we could describe TFC of human LV, we might be able to estimate the physical properties of the LV. However, no reports have demonstrated the response of human LV to minute forced vibration. The aim of this study was to clarify whether we could vibrate the LV noninvasively and to clarify the mode of vibration in human LV myocardium.

The vibrator (EV221 Matsushita Denko Co., Ltd, Osaka) was attached by hand to the anterior chest wall in seven normal subjects (23-34 years old) lying supine on the bed. We applied sinusoidal oscillation (30-100 Hz) with amplitude of 0.7 to 1.0 mm. The input signal was monitored by a miniature vibration sensor (1.5 g weight, EMIC 540M, Shin Nippon Sokki, Osaka) attached to the vibrator. Because we had confirmed experimentally that the transmission characteristics of the vibration through the esophageal wall was flat between 10 and 200 Hz, we measured forced LV posterobasal wall vibration by positioning...
the intraesophageal miniature vibration sensor just behind the LV (approx. 40 cm from the incisor teeth). The input signal, output signal and electrocardiogram were recorded on a magnetic tape recorder (Type FE-39A Sony Magnescale Inc., Tokyo). We examined the influence of the following factors on the mode of posterobasal LV wall vibration detected by the intraesophageal sensor: 1) respiration; 2) site of vibrator attachment on the chest wall; 3) body position.

The output vibration signal showed an amplitude modulation during the cardiac cycle, when the subject was lying at a 45° left anterior oblique supine position and when respiration was at expiration. Respiration exerted serious influence on the output signal. That is, during expiration, the output signal showed remarkable amplitude modulation caused by cardiac contraction. However, during inspiration, such modulation was not observed. The pattern of this modulation changed with the frequency of the input vibration (Fig. 1).

No significant change in output signal during the cardiac cycle was observed if the sensor was apart from the LV in the esophagus. Therefore, we concluded that this amplitude change during the cardiac cycle reflected the change in the physical nature of the LV. If the vibrational transmission characteristics of the thorax could be evaluated, e.g., by analyzing the heart sound transmission, we would be able to estimate instantaneous TFC in human LV myocardium. The remarkable change in vibration transmission during respiration might have resulted from the resonance of the system including the entire thorax and inspired lung.

This is the first clinical report that we could oscillate the LV from the precordial approach and demonstrate the mode of LV wall vibration. We concluded that it might be possible to evaluate noninvasively the physical properties of LV myocardium, analyzing modulation patterns of output signal.

References