Continuous Measurement of the Systolic Time Intervals Integrated on a Hemodynamic Profile. Successful Method to Monitor Left Ventricular Function

R. MUCHADA

The left ventricular contraction determines the generation of a force, the shortening of the ventricular walls, the blood ejection towards the aorta and the reduction of volume in the ventricular cavities.

The quality of the left ventricular contraction can be appreciated by its capacity to expulse a volume (pump function = stroke volume - cardiac output), by its ability to generate a force (measured indirectly by the time of increase of intraventricular pressure [Dp/Dt maximum]), by its shortening capacity (ejection fraction), by the time relation of contraction (Systolic Time Intervals, STI) and by the evolution of these different parameters.

Of all these parameters, the STI allow an estimation of the ventricular function taking into account only one variable, the time [1], which allows, when the time sequence measures are well defined, to reduce the possibility of methodological errors.

The measure of the STI has been largely used for the evaluation of the left ventricular performance variation [2]. Nevertheless, the introduction of new techniques, fundamentally the echo-Doppler cardiography, has progressively modified the interest for the STI.

This said, the measure of the STI can keep an important place in the evaluation of the left ventricular function if it is used as a parameter for monitoring, non invasively, in continuous way and integrated in a hemodynamic profile.

Measurement’s principle

The measure of the STI necessitates the identification of the beginning of the ventricular electrical stimulation, the opening and closing of the aortic valve.

The original principle necessitated the integration of three signals: the plethysmographic curve of the carotid pulse, the ECG signal, and a phonocardiographic signal [3].

These three signals allowed to detect the Q wave of the ECG, the opening and closing of the aortic valve on the mechanical events of the carotid pulse and...
the closing of the aortic valve on the first vibration of the second sound, given by the phonocardiogram.

The left ventricular ejection time (LVET) was represented by the time difference between opening and closing of the valve on the plethysmographic curve of the carotid pulse. The electromechanic systole (QS2) corresponded to the time between the Q wave of the ECG and the first vibration of the second sound given by the phonocardiogram. The difference between QS2-LVET calculated the pre-ejection period (PEP). With this method, it was impossible to measure directly the PEP since the opening of the aortic valve was detected with an unpredictable and irregular delay determined by the transmission of mechanical events on the arterial wall and cervical tissues.

The measure of the LVET and the QS2 allowing the secondary calculation of the PEP standardizes the calculation of the latest by avoiding the unpredictable variations.

The three signals were then saved on paper at a speed of 100 mm/s and the distance between the different events above described were measured for the data of the STI. The measures were made manually; the results were obtained with a delay in relation to the investigational needs.

Even though this method has had a certain success for the evaluation of the left ventricular performance [4], several critics could be made on it:

- the use of the three different systems to obtain the necessary signals implied three different constants of time (mechanic for the carotidian plethysmograph, electrical for the ECG, audible for the phonocardiogram);
- each time constant was influenced by the individual characteristics of the patient explored and the technical specifications of the measuring devices including that of the storing data system;
- the use of the three different sensors of which the positioning standardization was difficult to obtain, was surely an important obstacle for the repetitive measurement of the STI;
- the search for the "best" plethysmographic and phonocardiographic signals introduced a subjective part to it and therefore implied an important fluctuation of the measures obtained;
- finally, the STI were considered in an isolated way as evaluating tools to diagnose and prognose about the left ventricular function.

In terms of evaluation, the STI must be analysed in a context of a hemodynamic profile and its variations must be interpreted in parallel to the variation of other hemodynamic parameters included in a cardiovascular profile.

For all these reasons, the primary method had little reliability, sensitivity, reproducibility, precision and insufficient practicality to integrate the STI in a monitoring system.

*Cardiac echo-Doppler* improvements have rendered the STI measurements easier to make. The view of the aortic valve on a TM echographic image allows