

## **(2) Introduction**

### **2.1 Studies of atrial function**

In the field of cardiology, clinical and experimental cardiac research has focused primarily on ventricular function under normal and abnormal conditions. In contrast, the aspect of atrial performance has received less attention. Consequently, the data on atrial function particularly that of right atria are scarce [1]. Recent studies on left atrial function have shown that adequate atrial function is necessary not only for the proper overall circulatory system performance but also for optimal working of the whole human organism [2-7]. Augmented left atrial pump function is one of the mechanisms compensating for decreased early filling in patients with reduced ventricular compliance [8-11], whereas a loss of atrial contraction, as a result of atrial fibrillation or ventricular pacing, reduces cardiac output by approximately 16-20% [12, 13].

Congenital heart defects are a group of diseases which frequently involve the right heart with different kinds of abnormal morphologies. The right ventricle in patients with congenital heart disease is exposed to a wide spectrum of pressures and/or volume over-load. For example, in patients with atrial septal defect of secundum type (ASD), one of the most frequent acyanotic congenital heart disease, the right ventricle is volume over-loaded to varying extents. Whether right atrial function is altered under such conditions, especially after an atrium related procedure of ASD closure (surgery or intervention), remains unclear. Tetralogy of Fallot (TOF) is the most frequent cyanotic

congenital heart disease. Cardiac performance is of increasing importance for patients with surgically corrected tetralogy of Fallot because life expectancy has been prolonged. Long-term follow-up studies in these patients have demonstrated persistent right ventricular systolic and diastolic dysfunction [14-19]. Right atrial function in this group of patients may be more haemodynamically important than in normal subjects just like the role of left atrial function in the case of left ventricular dysfunction, but so far there is no study regarding the atrial function in postoperative TOF patients.

## **2.2 Methods of evaluation of the three main atrial functions**

The methods of evaluation of atrial function include transthoracic echocardiography, transesophageal echocardiography, magnetic resonance imaging and catheterization. Because of its noninvasiveness and convenience, 2-D echocardiography remains one of the most widely applied methods in the evaluation of atrial performance.

The atria have three main functions

\* Reservoir function (during the period of ventricular systole):

When the atrioventricular valves are closed during ventricular systole, the atria perform as easily distensible reservoirs. Blood flowing from the veins to the atrial chambers is unable to pass through the closed atrioventricular valves so it is stored in the atria causing their dilatation. Atrial reservoir function ends when the atrioventricular valves open [20-24].

\* Conduit function (passive emptying during ventricular relaxation and diastasis)

After the onset of ventricular diastole blood starts flowing from the atria to the ventricles. The first phase of ventricular filling is the equivalent of passive atrial emptying. In this stage, blood coming into the atrial chambers from the veins passes the atrioventricular ostia and enters the ventricles which work now as suckers. In this phase the atria act mainly as conduits [9, 20, 25-28].

\* Pump function (active emptying near ventricular end diastole).

At the second stage of ventricle dilatation, the atria contract, actively expelling the blood contained in their chambers into the ventricles. They serve as a booster pump. Atrial systole elevates ventricular end-diastolic tension and fiber length, thereby resulting in a more forceful and prolonged ventricular contraction which leads to increase in ventricular stroke volume [27, 29, 30].

### **2.3 Tissue Doppler imaging**

Tissue Doppler imaging (TDI) is a relatively new ultrasound technique that can quantify regional intramural myocardial velocities by the detection of consecutive phase shifts of the ultrasound signal reflected from myocardium instead of from the blood pool. It is based on the same principles as conventional Doppler blood flow imaging [31]. The first report dealing with myocardial motion by a pulsed Doppler single-time volume technique was published by Isaaz et al. in 1989 [32]. The technique has since been developed further. Now myocardial velocities may be recorded in the pulsed wave,

color-encoded M-mode or 2-dimensional mode. The velocity image information obtained by tissue Doppler imaging is less affected by tissue attenuation. With tissue Doppler imaging myocardial velocity can be accurately recorded and quantitatively analyzed during the whole cardiac cycle [33-39]. However, myocardial velocities detect regional motion as opposed to a regional deformation. Velocities may not directly characterize regional function because they are composed of a combination of motions induced by segmental contraction, overall heart motion, cardiac rotation and motion induced by contraction in adjacent segments [40-42].

The concept of myocardial strain was originally formulated by Mirsky and Parmley [43]. Strain and strain rate directly reflect regional myocardial function. Compared with velocities, strain and strain rate were shown to be less influenced by overall cardiac motion and tethering effects [36, 45, 46]. The 1-dimensional strain can be defined as ( $\epsilon = du/dr$ ), where  $u$  is displacement and  $r$  is the position along one axis. The temporal derivative of the strain, ie, the strain rate, is a measurement of the rate of deformation. It is equal to the spatial gradient of the velocity [44].

Noninvasive measurement of myocardial strain in humans was first made possible with magnetic resonance tomography [47, 48]. The main limitations of strain measurement by magnetic resonance tomography were a low sampling rate and a long examination time. Strain rate and strain measurements derived from tissue Doppler imaging were first introduced to quantify local changes in myocardial deformation in 1998 [44]. Compared with magnetic resonance imaging tagging, TDI offers a superior real-time temporal resolution and can be performed at the bedside. Through the studies both in phantoms

and in clinical settings tissue Doppler imaging derived strain rate and strain have been validated as a promising method for the quantitative evaluation of regional myocardial function [37-39, 44, 49, 50]. Up until now studies on the evaluation of atrial function using tissue Doppler imaging are scarce.