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Zeliha KURTOĞLU[1]
M. Haluk ULUUTKU[2]

An Alternative Method to the Volume Estimation of Cavities with Irregular Surface in the Cadaver: Measuring Right Cardiac Ventricle of the Fetus by Using Mercury

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[1]Department of Anatomy, Faculty of Medicine, Mersin University, Yenişehir, 33160, Mersin, [2]Department of Anatomy, Faculty of Medicine, Karadeniz Technical University, 61080, Trabzon - TURKEY

Abstract: To find the volume of irregular cavities in cadavers, many researchers have used different methods including filling with any fluid and calculating the volume by usingcomplex geometrical formulas. All of these have some difficulties and disadvantages. In this paper, filling cavities with mercury is presented as an alternative method for volume estimation of the cavities. The volumes of 22 right cardiac ventricles were found by using mercury in 27-34 week-old fetuses. The method was proposed as an easy and sensitive method for volume estimation and comparison of the cavities in the cadaver.

Key Words: right cardiac ventricle, mercury, volume estimation, fetus

Introduction

Because the dimension of any organ is meaningful in clinical and morphological aspects, it is evaluated by using different techniques in live subjects. Nowadays, advanced instruments such as computed topography, magnetic resonance imaging, and ultrasound help in measuring the dimensions (1-7). These methods are based on calculating the area or volume by using a combination of some geometrical shapes. In this way, it is possible not only to obtain the basic measurements such as length, height and width, but also to estimate the volume by analyzing complex formulas.

Obtaining the basic measurements for calculation of the volume is not easy in direct investigations of the cadaver. Some authors propose the use of geometrical shapes such as cones, truncated cone, spheres, and ellipses, (8-11). Filling by liquid has also been used as an effective method for years. Beneke (1879) and Hegglin (1934) determined the volume of the ventricular cavity by using this method (12). In 1934, Schummer filled the vessels and other cavities with plastoid, which would harden just after the application. After that, different researchers used substances such as vinyl, resin, latex, gelatin, and polyvinyl chloride.

It is suggested that filling with mercury has some advantages in finding the volume of cavities with irregular surfaces. In this study, the volume of the right ventricle, an example of such a cavity, was found by using mercury.

Materials and Methods

A mercury utilizing method was applied to the right ventricle of 22 fetuses aged 27-34 weeks. The fetuses were obtained from the Pathology Laboratory. All the specimens were conserved in formalin solution for at least several months.

The initial weight of the mercury in a definite volume (i.e. specific weight) was calculated by using the following method. Mercury was weighed repeatedly at 24ºC room temperature by using a Qertling NA164 balance sensitive to 0.1 mg. Average weight was found to be 14.6044 ± 0.430 g/ cm^3. This value was used in the calculation of the volume of the right ventricle using the formula below;

$$\text{Volume of the right ventricle} = \frac{1\ (cm^3)}{14.6044\ (g)}$$

X measured value (g)

(measured value: weight of the mercury filling the right ventricle.)

To find the volume of the ventricles, the following steps were applied to the hearts:

- Each atrium of the hearts was removed. Blood clots, possibly takeing up room in the ventricle were removed and washed out with water and then dried out.

- The heart was placed on synthetic foam in a vertical position. Then, the foam was put on the sensitive balance. Tricuspid and pulmonary orifices were brought on to the same plane. The balance was calibrated.

- After that, the ventricle was filled with mercury through the tricuspid orifice. When mercury was seen at the pulmonary orifice, the weight was measured. This measurement was repeated ten times for each right ventricle by the same researcher.

- Arithmetic average of these values were placed in the formula above, and the calculation gave the volume of the ventricle.

Results

Measurements of the right cardiac ventricles of the 22 fetuses by using mercury are summarized below: the minimum value was found to be 0,1581 cm^3, the maximum value as 1,7973 cm3, and the mean value as 0,6653 cm^3 for the volume of the right ventricular cavity (SD: 0,4300). There was found to be a correlation between age and the measurements.

Discussion

Geometrical models allow evaluation of live subjects using the sectional imaging methods. The most important factor affecting the reliability of the results is the accuracy of representation of the cavity by the geometrical model. Irregularity of the cavity makes estimation harder. Furthermore the model described for a normal organ can not be used for organs having congenital or pathological varieties (4, 11, 13).

About the estimation of the volume of the right cardiac ventricle, Alvarez et al. proposes a geometrical model, in which the ventricle is split into two parts: inlet and outlet. Each part is represented by a cone in the distal and a truncated cone in the proximal. The border between the cone and truncated cone is described at the proximal third of the inlet length and at the proximal fifth of the outlet length. But those levels may be placed more proximally or more distally. In addition the ellipsoid expansion at the proximal part of the inlet has not been taken into consideration (8, 11). In that model, volumes of the papillary muscles, trabeculae carneae and position of the interventricular septum are not taken into account in the calculation. (8,11). As a result, the geometrical method is very poor in representing the right cardiac ventricular cavity, and we suggest that it needs additional geometrical calculations.

The present method can cope with all of these circumstances due to its nature without requiring any more procedures. However, the geometrical method has superiority in live subjects because of its adaptability on instruments like MRI, CT, and USG.

Filling the cavity with solidifying liquid, and then taking the tissue away and calculating the solid substrate's volume may be an alternative method in the estimation of the volume of the cavity (14). This is an effective method for measuring the volume of the irregular cavities. But it does not let the researcher repeat the measurement. And the method limits the study with respect to taking histo-pathological specimens, because it requires the protecting of the tissue continuity before filling, and then the whole tissue has to be removed.

It is also possible to estimate the volume by filling the lumen with a fluid liquid and transferring it into a measure. The liquid should allow the procedure to be repeated without adhering to the walls of the cavity, fill the whole indentation without allowing any bubbles for reliability of the measurements and not diffuse into the tissue. All the same, in this method the risk of error increases, because it needs two phases, filling the cavity and then emptying the liquid into a measuring instrument.

It is proposed in the present study that using a substance with a high specific weight (like mercury) to fill the cavity and weighing, instead of measuring the volume by any other instrument, decreases the error. In this study, the right cardiac ventricles of the 22 fetuses, at 27-34 weeks, were measured by using mercury. The results indicated that the measurements showed small differences, which were in accordance with increasing weeks of age. Changes in the dimensions of the fetus in the third trimester are well known. The cardiac volume is also expected to enlarge to supply the body's needs. The method exposes the alteration of the right ventricle in the eighth week of the third trimester.

A disadvantage of the method is that the bigger volume cavities such as the urinary bladder, abdominal cavity or adult cardiac ventricle, required much more mercury, and might decrease the sensitivity. Additionally this method is useless in some congenital abnormalities such as ventricular septal defects.

The other disadvantage of studying with mercury is that direct contact or inhalation of it may cause poisoning. During the study, this problem was overcome by using conservative instruments and a fan system respectively (15).

Consequently, mercury-using method could be effectively applied to volume estimation and for comparison of the small cavities and lumens in cadavers. The advantage of the method is its easiness and sensitivity for small cavities or lumens with irregular surfaces, such as renal pelvis, paranasal sinuses, tympanic cavity, fetal uterine cavity, cardiac and cerebral ventricles.

Correspondence author:
Zeliha KURTOĞLU
Mersin University,
Faculty of Medicine,
Department of Anatomy, Yenişehir,
33160, Mersin-TURKEY

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