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ECHOCARDIOGRAPHIC LEFT VENTRICULAR SIZE IN THE SELECTION OF SURGICAL TREATMENT IN PATIENTS WITH TETRALOGY OF FALLOT*

*Süheyla Özkutlu MD**, Muhsin Saraçlar MD***, Şencan Özme MD***
Yurdakul Yurdakul MD*****

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Among cyanotic congenital heart diseases, tetralogy of Fallot is the most common condition. It has been demonstrated that the left ventricle is smaller than normal in size in this condition[1-7]. In addition, it is believed that a small left ventricle indicates a somewhat greater risk of complete repair[6,8-11]. Some centers consider this to be an indication for a shunt operation, rather than open-heart repair, with the expectation that the resulting increase in pulmonary venous return will improve the capacity of the left heart with time[8].

The studies conducted on the effect of left ventricular size in the success of total correction of tetralogy of Fallot are limited in number[6,7,10-12]. To illuminate this subject we studied 56 cases with tetralogy of Fallot. The left ventricular dimensions were measured by M-mode echocardiography before surgical treatment and the size of the left ventricle and operative success were correlated.

Material and Methods

Fifty-six patients in which the diagnosis of tetralogy of Fallot was made by cardiac catheterization and angiocardiography were the subjects of this study. There were 17 girls and 39 boys and their ages ranged between three and sixteen years. Echocardiographic examinations were performed with a Smith-Kline Echoline 20 diagnostic ultrasonoscope combined with an Echoline 21 recorder. A 2.75 MHz

* From the Departments of Pediatrics and Pediatric Cardiology, Hacettepe University Institute of Child Health, Ankara.

** Associate Professor of Pediatrics and Pediatric Cardiologist, Hacettepe University Institute of Child Health.

*** Professor of Pediatrics and Pediatric Cardiologist, Hacettepe University Institute of Child Health.

**** Professor of Cardiovascular Surgery, Hacettepe University Faculty of Medicine.

transducer was used. Photographic records were made on Kodak Type 2295 linagraph paper. Electrocardiograms (D_2 derivation) were simultaneously recorded. The Q wave or the beginning of the R wave was chosen to determine the time of onset of electrical systole. The examination was performed in the supine position in the manner previously described by Feigenbaum[13]. The records were taken at a speed of 50 mm/sec. The time lines of one second and the calibration points indicating one centimeter were recorded.

The end-diastolic dimension was measured from the septal surface to the left ventricular endocardium at the time of onset of ventricular depolarization as indicated by the Q or R wave of the simultaneous electrocardiogram. These measurements were made at least in three cardiac cycles, and their mean values were obtained. Then the figures were corrected according to the calibration factor and were correlated with the figures of normal children indexed according to body weight as described by Gutgesell and Paquet[14].

The significance of the difference of the echocardiographic mean values was investigated by means of the Student's *t* test. Furthermore, in order to determine the linear relationship between the echocardiographic measurements (y = dependent variables) and the body weight of the patients (x = independent variables), the multiple linear regression analysis method was used. These statistical procedures were carried out at the Haçettepe University Data Processing Center.

Results

In accordance with the operation results, the subjects were divided into two groups. Group I consisted of 43 patients who had survived and Group II, 13 patients who had died. In Group I, the ages ranged between three and sixteen years (mean 8.4) and in Group II the ages ranged between three and sixteen years (mean 6).

The relationship between the left ventricular end-diastolic dimension and the body weight of the patients of Group I showed an r value of 0.53 (Fig. 1). This value was significant statistically ($t = 4.013$, $p < 0.01$), and indicates an enlarged left ventricular size. The same relationship for Group II was found with an r value of 0.339 (Fig. 2) which was statistically insignificant ($t = 1.199$, $p > 0.05$).

The mean values of the left ventricular end-diastolic dimensions of the patients were found to be 26.32 ± 1.097 mm in Group I, and 21.46 ± 0.806 mm in Group II. The difference between the mean values of the two groups was significant statistically ($t = 3.57$, $p < 0.05$). The difference between the mean values of the patients' ages of these two groups which were 8.38 ± 0.61 and 5.96 ± 0.93 for Group I and Group II, respectively was also statistically significant ($t = 2.14$, $p < 0.05$).

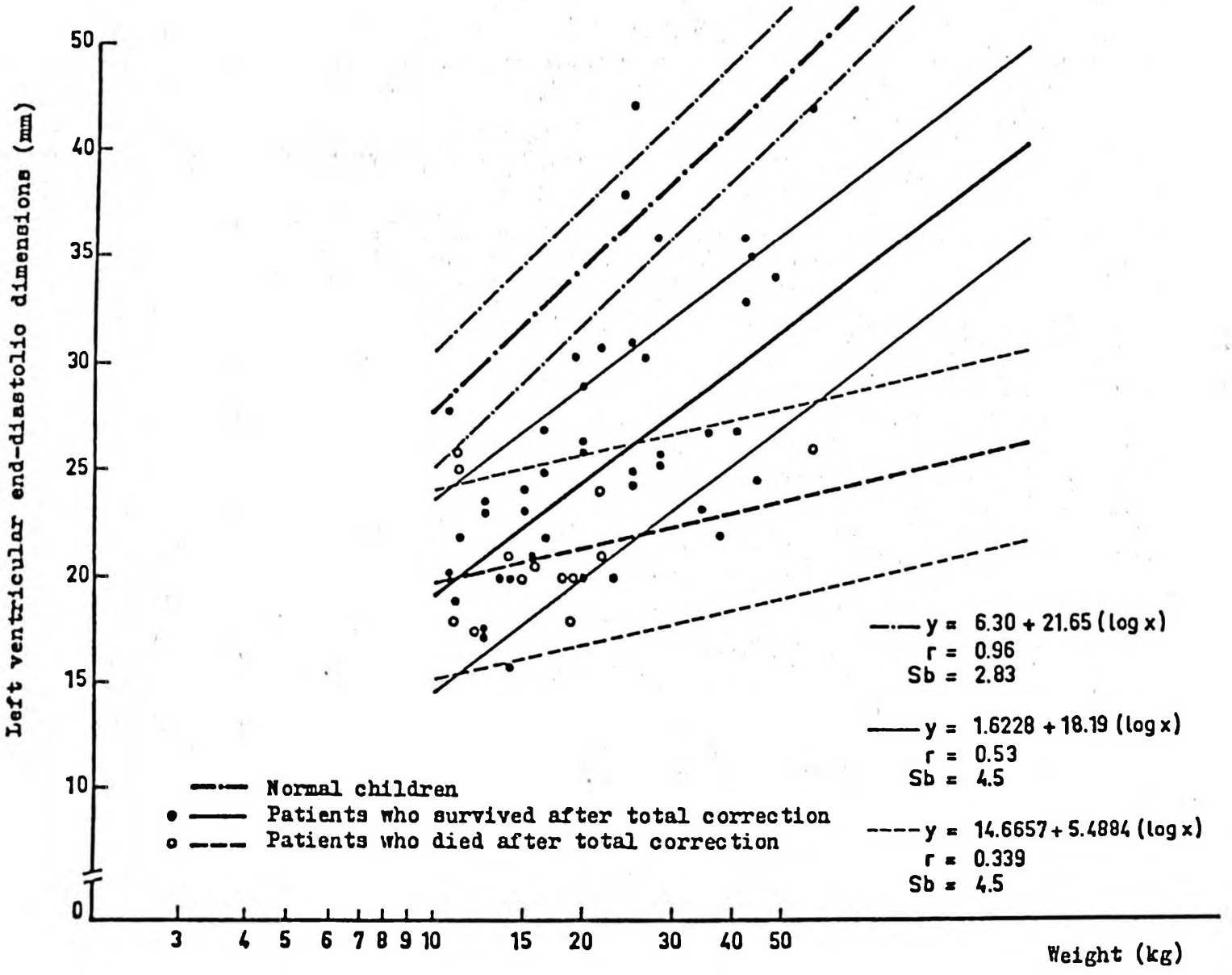

Fig. 1: Relationship between the left ventricular end-diastolic dimension and the body weight of normal children and patients with tetralogy of Fallot.

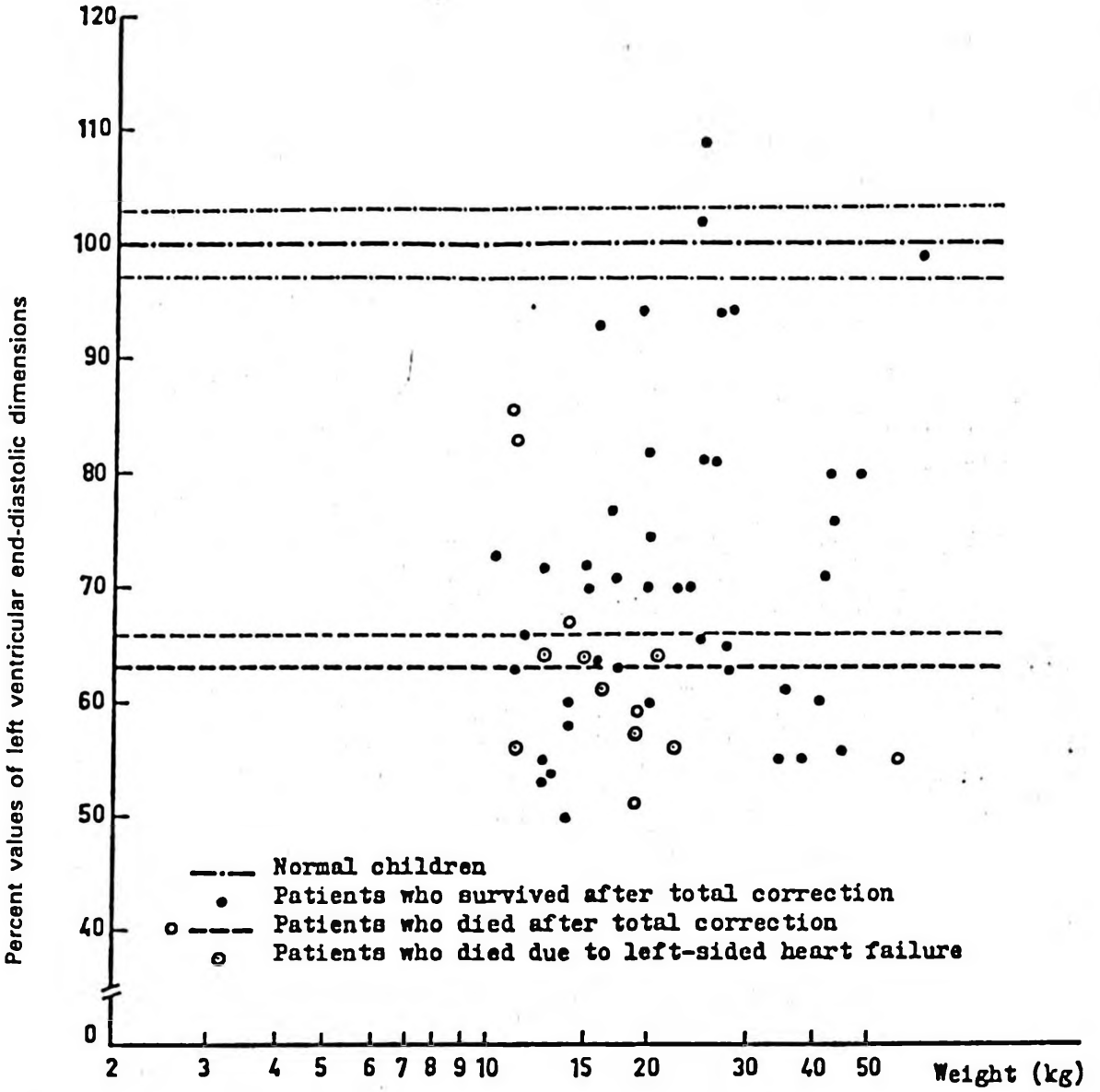

Fig. 2: Relationship between the percent values of the left ventricular end-diastolic dimension and body weight.

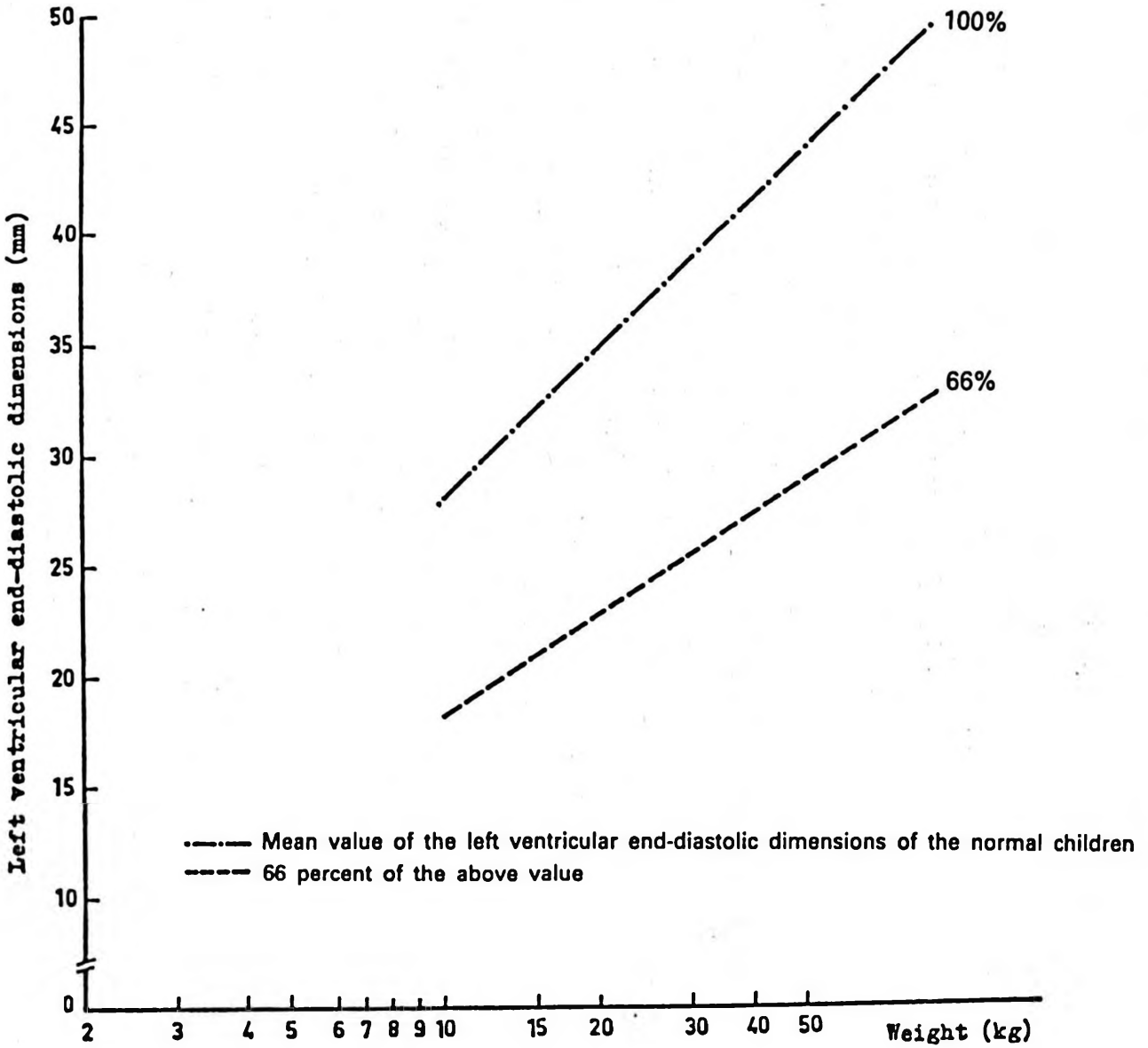

Fig. 3: Mean value of the left ventricular end-diastolic dimensions of the normal children and 66 percent of the lower values of this figure.

The mean value of the end-diastolic dimension was 71 ± 2.15 percent (with a range between 50 and 109) of normal in Group I, and 63 ± 2.91 percent (with a range between 51 and 96) of normal in Group II.

A patch enlarging the right ventricular outflow tract was used in seven patients in Group II. The right and left ventricular systolic pressure ratio was found to range between 0.42-0.66 in six of the seven cases, that is, there was no outflow tract obstruction. The right and left ventricular pressures were not measured in Case No. 6. Four of these patients were operated on again because they exhibited the low cardiac output syndrome. Neither considerable hemorrage nor pericardial fluid was seen in any of these subjects. The cause of death of these patients is indicated in Table I.

TABLE I: Cause of Death of the Patients

		Cases with outlow patch	
Case No.	LVEDD* value (%)	Left-sided heart failure (cause and date of death)	Other
1	86		5th day arrhythmia
2	57	4th day	
3	61	48 hrs.	
4	64	48 hrs	
5	56	48 hrs	
6	83		48 hrs right-sided failure
7	67		48 hrs arrhythmia

* LVEDD: Left ventricular end-diastolic dimension.

In the remaining six patients in which the right ventricular outflow tract graft was not needed, the right and left ventricular pressure ratio was found to range between 0.66-0.94, that is, there was no outflow tract obstruction. The cause of death of these patients is indicated in Table II.

The patients who survived and whose left ventricular end-diastolic dimensions were below the 66 percent line (see discussion) needed dopamine during the early postperative period.

TABLE II: Cause of Death of the Patients

		Cases without outflow patch	
Case No.	LVEDD* value (%)	Left-sided heart failure (cause and date of death)	Other
1	59		48 hrs convulsion
2	55		48 hrs arrhythmia
3	51		48 hrs arrhythmia
4	64	48 hrs	
5	63	48 hrs	
6	58	48 hrs	

* LVEDD: Left ventricular end-diastolic dimension.

Discussion

We evaluated the size of the left ventricle by measuring the end-diastolic diameters as described by some authors. Any small error made in determining the left ventricular dimension is magnified when the volume is calculated since the measurements are cubed[7]. For the standardization of echocardiographic measurements, some authors[14] use the body weight, and others[7], the body-surface area.

When the relation between the left ventricular end-diastolic dimension and the body weight (r = 0.53) of the patients with tetralogy of Fallot, who survived after corrective surgery (Group I), is compared to the data obtained by Gutgesell and Paquet[14] from normal children (r = 0.96), it is understood that our value is not as significant as that of these authors. This may be interpreted to mean that the left ventricles of the patients with tetralogy of Fallot show slower improvement as compared to the normal, however the pulmonary venous return is adequate. The relationship between the left ventricular end-diastolic dimension and the body weight of the patients who died after total correction (r = 0.339, Group II) has also been compared to the normal values of Gutgesell and Paquet[14] (r = 0.96) and our cases in Group I (r = 0.53). The r value in Group II is rather different from the others, that is, it may be interpreted to mean that as the body weight increases, the left ventricle of the cases in this group shows much slower improvement, or in other words, the pulmonary venous return does not result in an adequate left ventricular size.

There are other studies[3,10-12] in which the left ventricular end-diastolic volume has been measured from cineangiograms. Miller et al[3] have found that the left ventricular end-diastolic volume was 70 percent of normal with the exception of two severe cases whose values were less than 60 percent of normal. One of these two cases died due to left-sided heart failure and pulmonary edema postoperatively after corrective surgery. Graham et al[1] has found the left ventricular end-diastolic volume to be greater than 65 percent of normal. They reported that a three-year-old child whose left ventricular end-diastolic volume had been about 45 percent of normal died due to left-sided heart failure. For this reason, they proposed that the shunt operation be carried out on cases whose left ventricular volume was less than 55 percent of the normal. Setsuie et al[10] recommended an initial shunt procedure in patients with an end-diastolic volume index of less than 40 ml/m^2, based on experience of four operative deaths in five patients with decreased left ventricular volume as a result of left-sided heart failure. Naito et al[11] recommended that an end-diastolic volume index of at least 30 ml/m^2 is required for successful primary repair and that for patients with an end-diastolic volume index of less than 30 ml/m^2, palliation by the systemic-to-pulmonary arterial shunt procedure should be indicated.

In the M-mode echocardiographic studies of Oberhansli and Friedli[7], the left ventricular end-diastolic dimension was found to be 85.4 ± 1.9 percent (with a range between 65 and 105 percent) of normal. It has been recorded that young children with severe left ventricular hypoplasia have a higher corrective surgery mortality even though several were successfully operated on with left ventricular diameters of only 65 pecent of normal.

According to studies, the left ventricular end-diastolic volume or diameter in the patients with tetralogy of Fallot is less than normal. In particular, the sizes of the left ventricles of the patients who died after total correction were rather different from the normal and from those who had survived. Neverthless, a percentage of the cases with small left ventricles either had a stormy postoperative course with left ventricular failure or died after surgery. This fact indicates that the size of the left ventricle should be considered a critical factor in determining the feasibility of intracardiac repair of tetralogy of Fallot.

When we review the distribution of the cases in Group II (Fig. 2), it is understood that the three cases over the 66 percent line which represents the upper limit of the mean percent of the exitus line, died due to right heart failure. In the case whose right and left ventricular pressures could not be measured after placement of a patch to the right ventricular outflow tract, the left ventricular end-diastolic dimension was 83 percent of normal. The other two cases with rhythm disturbances had a left ventricular end-diastolic dimension of 86, which was 67 percent of normal. The marked seven cases being below the 66 percent line died due to the findings of tachycardia, tachypnea, pulmonary crepitant rales, hypotension and bleeding from the endotracheal tube which result from left-sided heart failure. Below the 66 percent line, death was a result of rhythm disturbances and convulsions after surgery. It is seen that 70 percent of our patients in which the left ventricular end-diastolic dimensions were below the 66 percent line died as a result of left-sided heart failure. That is, according to our data, 35 percent of the cases whose left ventricular end-diastolic dimensions were below 66 percent of normal died while 70 percent of them died because of left-sided heart failure.

Consequently, when the left ventricular end-diastolic dimension or volume is less than a certain level, we can say corrective surgery will lead to a rather stormy postoperative course because of left-sided heart failure. It is therefore concluded that for successful primary repair, a left ventricular dimension above a certain level is necessary, while for patients with a left ventricular end-diastolic dimension or volume of less than a certain level, palliation by the systemic-to-pulmonary arterial shunt procedure should be indicated. In view of our data, we suggest that the limit line for the left ventricular end-diastolic dimension be 66 percent of the normal values as the criterion for corrective surgery or a shunt operation (Fig. 3).

Summary

Fifty-six cases with tetralogy of Fallot are presented. The left ventricular dimensions of the subjects were measured by M-mode echocardiography before undergoing surgical treatment. After surgery the patients were divided into two

groups. Group I consisted of 43 patients who had survived· Group II consisted of 13 patients who had died. The age ranges were between three and sixteen years in both groups. The mean values of the left ventricular end-diastolic dimensions (LVEDD) were 71 ± 2.15 percent (with a range between 50 and 109) of normal in Group I, and 63 ± 2.91 percent (with a range between 51 anu 96) of normal in Group II ($t = 3.57$, $p < 0.05$). The relationship between the LVEDD and the body weight of the patients in Group I showed an r value of 0.53 ($p < 0.01$) which means that as the body weight increases the left ventricular size becomes more enlarged. However, no such relationship was present in Group II ($r = 0.339$, $p > 0.05$). It may be presumed that with the increase in body weight, the left ventricular size of the cases in this group showed much slower improvement. According to our data, 35 percent of our cases (Group II) whose LVEDD fell below 66 percent (upper limit of the mean percent of the exitus line) of normal died, while 70 percent died because of left-sided heart failure.

It is concluded, therefore, that for successful primary repair, a left ventricular dimension above a certain level is necessary, and we suggest that the limit line as an indication for corrective surgery or shunt operation be 66 percent of the normal values.

REFERENCES

1. Lev M, Eckner FA. The pathologic anatomy of tetralogy of Fallot and its variations. *Dis Chest* 45:251, 1964.
2. Lev M, Rimoldi JA, Rowlatt UF. The quantitative anatomy of cyanotic tetralogy of Fallot. *Circulation* 30:531, 1964.
3. Miller GA, Kirklin JW, Rahimtoola SH, et al. Volume of the left ventricle in tetralogy of Fallot. *Am J Cardiol* 16:488, 1965.
4. Kirklin JW, Karp RB. *Tetralogy of Fallot from a Surgical Viewpoint.* Philadelphia: WB Saunders Co, 1970, p 189.
5. Nagao GI, Daoud GI, McAdams AJ, et al. Cardiovascular anomalies associated with tetralogy of Fallot. *Am J Cardiol* 20:206, 1967.
6. Jarmakani JM, Graham TP Jr, Canent RV Jr, et al. Left heart function in children with tetralogy of Fallot before and after palliative or corrective surgery. *Circulation* 46:478, 1972.
7. Oberhänsli I, Friedli B. Echocardiographic study of right and left ventricular dimension and left ventricular function in patients with tetralogy of Fallot before and after surgery. *Br Heart J* 41:40, 1979.
8. Guntheroth WG, Kawabori I, Baum D. Tetralogy of Fallot. In Adams FH, Emmanoulidies GC (eds). *Moss' Heart Disease in Infants, Children, and Adolescents* (3rd ed). Baltimore: Williams & Wilkins, 1983, p 215.
9. Ebert PA, Sabiston DC Jr. Surgical management of the tetralogy of Fallot: Influence of previous systemic pulmonary anastomosis on the results of open correction. *Ann Surg* 165:806, 1967.
10. Setsuie N, Yokota Y, Makino S, et al. Operative results and postoperative prognosis in total correction for infants and children with tetralogy of Fallot. *Jpn J Operation* 33:935, 1979.

11. Naito Y, Fujita T, Yagihara T, et al. Usefulness of left ventricular volume in assessing tetralogy of Fallot for total correction. *Am J Cardiol* 56:356, 1985.
12. Graham TP Jr, Faulkner S, Bender H Jr, Wender CM. Hypoplasia of the left ventricle: rare cause of postoperative mortality in tetralogy of Fallot. *Am J Cardiol* 40:454, 1977.
13. Feigenbaum H. *Echocardiography* (2nd ed). Philadelphia: Lea & Febiger, 1976, p. 55.
14. Gutgesell HD, Paquet M. *Atlas of Pediatric Echocardiography.* New York: Harper & Row, 1978, p 206.