Indications for Radical Correction of the Common Arterial Trunk with High Pulmonary Hypertension

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Thirty-nine patients with a diagnosis of common arterial trunk and high pulmonary hypertension were examined. Radical correction of the anomaly was performed in 22 patients with a hospital lethality of 36%. Residual pulmonary hypertension was the cause of death in all cases. Results of surgical treatment as well as the indexes of hemodynamics and biopsy and autopsy data were analyzed during the investigation.

Key Words: *congenital heart disease; common arterial trunk; pulmonary hypertension*

Common arterial trunk (CAT) is one of the most complicated congenital heart diseases with a frequency of occurrence of 2.8-4.6% [5,12]. Anatomically the anomaly is characterized by a sole vessel withdrawing from both ventricles communicating with each other through a defect in the interventricular septum. The most serious complication of the natural course of the disease is a marked circulation failure due to massive pulmonary blood flow (PBF) and progressive pulmonary hypertension (PH) [13]. Only 50% of newborns survive the first month of life and only 12% survive the first year [12]. Timely correction of this defect averts the development of PH and lowers the hospital lethality rate to 10% [4,11,15]. Rapidly progressing PH (from 3 to 6 months, as a rule [4]) can raise the surgical lethality to 30-39% [8,14]. The majority of authorities advise performing radical correction of this anomaly in the first few months of life [4,6,11]. The analysis of lung biopsy used to assess the seriousness of lung-vascular alterations showed that reversible changes dominate in infants under 6 months [11]. This is confirmed by Ebert's data [9] on the absence of PH progression if the operation is performed during the first 6 months of life. When the anomaly is corrected at a later age or when there is a high total pulmonary resistance (TPR) at the time of operation (more than 8 units/m^2 according to C. Marcelletti), the long-term servival is no more than 68% [8,15]. These findings prompted efforts to establish operability criteria for this defect in case of high PH. Mair and co-authors [13] reported that a decrease of the arterial saturation (SO_2Ao) below 80% points to high pulmonary resistance which rules out radical correction. According to Mayo Clinic data, the operation is contraindicated for all patients more than 2 years old with TPR higher than 8 units/m^2. The analysis performed by Lepikhova and co-authors [3] identified hemodynamic criteria for the degree of seriousness of the lung-vascular changes described in Heath-Edwards (H-E) classification. The present investigation was undertaken to specify indications for radical correction of CAT based on morpho-hemodynamic parameters and results of surgical treatment.

MATERIALS AND METHODS

Thirty-nine patients aged from 5 months to 10 years with CAT were examined at the Research

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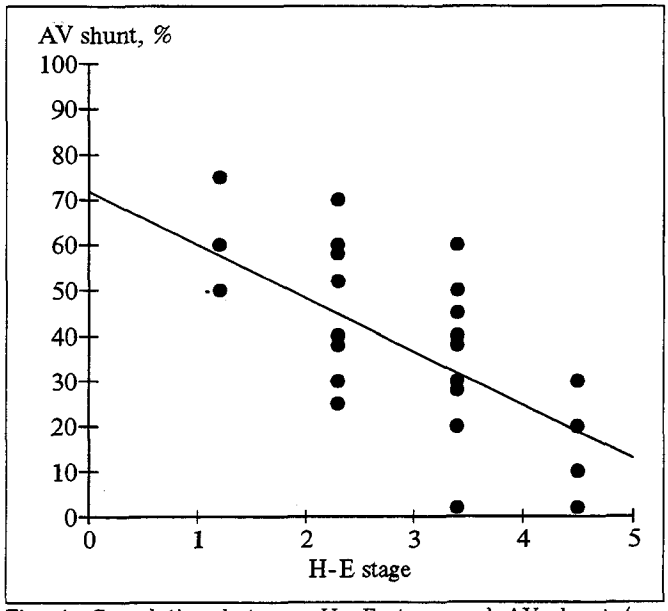

Fig. 1. Correlation between H–E stage and AV shunt (r = = −0.702).

Center of Cardiovascular Surgery between 1987 and 1993. Twenty-six had the 1st type of anomaly and 13 had the 2nd type according to Collett-Edwards classification. Radical correction was performed in 22 patients. In addition to routine clinical examination patients underwent cardiac catheterization and open lung biopsy. The hemodynamic indexes studied during catheterization were as follows: the degree of PH, the mean pressure in the pulmonary artery (MPPA); TPR, ratio of TPR to the systemic peripheral resistance (TPR/SPR); PBF, the ratio between PBF and the systemic circulation (PBF/SC); the arteriovenous (AV) shunt, and oxygen saturation of the blood in the aorta (SO_2Ao) and in the pulmonary artery (SO_2PA). Twenty-five patients underwent open lung biopsy. The morphological changes of pulmonary vessels were studied according to autopsy data in 8 patients. The stage of the morphologic changes was assessed by H-E classification [10] as well as the following morphometrical parameters: the index of the width of the tunica media (IWTM), which reflects the degree of media hypertrophy at the level of the terminal bronchiole arteries (TBA) and respiratory bronchiole arteries (RBA) and the mean diameter of the same arteries (MTBA and MRBA). The obtained data were compared with PPA after correction of the anomaly. The findings were processed using KWIKSTAT statistical software.

RESULTS

Eight of the 22 operated patients died. The hospital lethality was 36%. Pronounced right-ventricle failure against the background of residual high PH was the cause of death in all cases. Hemodynamic parameters prior to surgery in the whole group attested to the high PH: PH was 94±11%, MPPA 61±11 mm Hg, TPR 12±7 units/m², TPR/SPR 0.69±0.36, PBF 7±3 liters/min/m², PBF/SC 1.7±0.8, AV shunt 42±18%, SO_2Ao 88±5%, and SO_2PA 80±6%. The analysis of the morphological changes occurring in pulmonary vessels revealed the 1st-2nd stage according to the H-E classification in 4 patients, the 2nd-3rd stage in 11 patients, the 3rd-4th stage in 11 patients, and the 4th-5th stage in 7 patientss. Mean morphometric parameters were as follows: IWTM TBA 23±8%, IWTM RBA 23±6%, MTBA 0.22±0.05 mm, and MRBA 0.08±0.02 mm and testified to a marked hypertrophy of the tunica media of preacinar and intraacinar vessels and to their marked dilation.

The correlation analysis showed that the degree of morphological changes according to the H-E classification depended markedly on TPR/SPR (correlation coefficient r=0.594), with PBF/SC (r=-0.654), AV shunt (r=-0.702), and SO_2Ao and SO_2PA (r=-0.664 and r=-0.640, respectively) (Fig. 1). Therefore, as the morphological changes in vessels of the pulmonary circulation (PC) increse, the correlation between the resistances in both cir-

TABLE 1. Mean Hemodynamic and Morphometric Parameters at Various Stages after Heath–Edwards (n=33)

Index	H-E stage			
	1-2	2-3	3-4	4-5
PBF/SC	2.7*	1.6	1.4*	0.9
AV shunt, %	61*	43	31*	19
SO_2Ao, %	95*	88	86*	82
SO_2PA, %	87	79	79*	73
PPA postoperation, mm Hg	61	69*	90	82
Age, months	20	30	39	61
Number	4	11	11	7

Note. Here and in Table 2: an asterisk signifies the reliability of differences at p<0.05.

culations increases and the AV shunt as well as PBF diminish. This results in a decrease of blood oxygenation in the pulmonary artery, and when the arteriovenous shunt increases, it leads to hypoxemia. These findings are in line with those we obtained previously [1,2] in the case of an isolated defect of the interventricular septum with high PH and attest to the similarity of the mechanisms of development of hypertension in these anomalies. The value of PPA after radical correction of the anomaly depended directly on the H-E stage (r=0.581) and inversely on the AV shunt (r=-0.620) and MTBA (r=-0.897) (Fig. 2). The more serious the morphological changes (the more pronounced the sclerosis and obturation of the vessel lumen with a decrease of the AV shunt), the higher the residual pressure in the pulmonary artery after surgery. Dilatatory changes of the vascular wall manifested in an increase of its external diameter are typical for the 4th and later H-E stages, which is what determined their dependence on the residual PH.

To obtain the hemodynamic criteria of the seriousness of the vascular changes all data were correlated with H-E stages (Table 1).

Table 1 shows the hemodynamic criteria of the 1st-2nd and 4th-5th stages according to H-E. The 1st-2nd stage is characterized by the following parameters: PBF/SC>2.7, AV shunt >61%, the absence of hypoxemia (SO_2Ao >95%), and SO_2PA>87%, while PBF/SC<0.9, AV shunt <19%, hypoxemia less than 82%, and SO_2PA below 73% were typical for the 4th-5th stages. These results correspond on the whole to those obtained by Lepikhova and coauthors [3].

The lowering of the pressure in the pulmonary artery was more significant in the 1st-2nd and 2nd-3rd stages and reliably differed from the data noted in patients at the 3rd-4th and 4th-5th stages.

Thus, just the hemodynamic parameters make it possible to assess reliably the initial and, at the same time, very far advanced lung-vascular changes and to determine the surgical strategy. As far as the 2nd-3rd and 3rd-4th H-E stages are concerned, the absence of any significant difference in the hemodynamic data precludes the specification of any particular one.

Further analysis was performed in light of the results of the surgical treatment. Based on this, the patients were divided into 2 groups. Fourteen patients who successfully withstood the operation comprised the first group. The second group consisted of 8 patients who died from the residual high PH after the operation. The data of hemodynamics, morphology of lung-vascular changes,

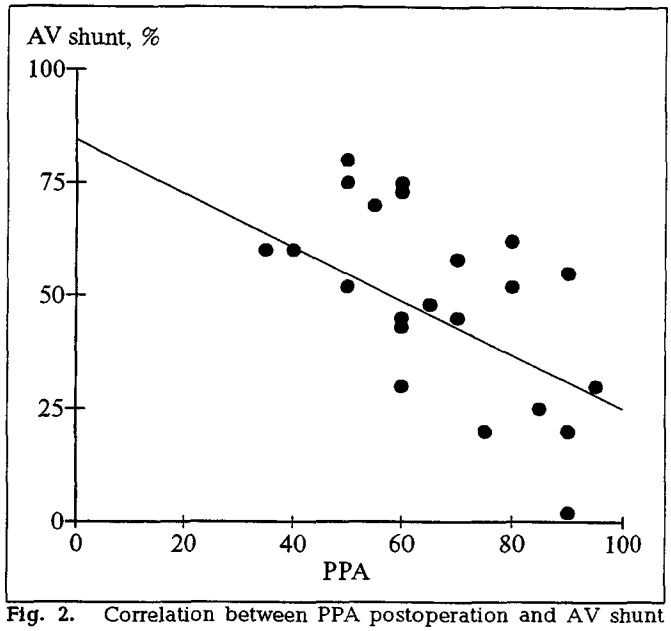

Fig. 2. Correlation between PPA postoperation and AV shunt (r = −0.620).

and PPA postoperation were compared in the two groups (Table 2).

The reliable difference in hemodynamic parameters found in these two groups permits surgery to be ruled out if a patient has PBF/SC<1.3, AV shunt<27%, hypoxemia lower than 86%, and SO_2PA<78%.

No patient who came through the operation had morphological changes of PC vessels exceeding the H-E 2nd-3rd stage, whereas in patients who died they varied from the 2nd-3rd to 4th-5th stage. However, in no surviving patient did PPA not normalize and not exceed 30 mm Hg. Only in 2 patients was it lower than 50 mm Hg, while in the others it ranged from 60 to 80 mm Hg. The correlation analysis performed in the group of surviving patients dieclosed that PPA postoperation is primarily determined by the value of TPR (r=0.616), the H-E stage (r=-0.870), and, to a

TABLE 2. Postoperative Hemodynamic and Morphological Parameters and PPA Depending on the Outcome (n=22)

Index	First group	Second group
Age, months	31±12	50±33
TPR/SPR	0.40±0.13	0.91±0.53*
PBF/SC	2.3±0.7	1.3±0.6*
AV shunt, %	57±15	27±17*
SO_2Ao, %	91±3	86±3*
SO_2PA, %	83±4	78±3*
PPA postoperation, mm Hg	60±11	85±9*
H−E stage	1−2, 2−3	2−3, 3−4, 4−5

lesser degree, by TPR/SPR (r=0.470) as well as PBF/SC (r=-0.438). PPA remains higher in patients with increased TPR as well as at the 2nd-3rd stage as compared to the 1st-2nd.

The final analysis was performed in the group of patients with the 2nd-3rd H-E stage of morphological changes in view of the fact that there were both survivors and nonsurvivors. Three surviving patients had the following hemodynamic indexes: TPR/SPR 0.41±0.14, PBF/SC 1.9±0.2, AV shunt 53±20%, and PPA postoperation 63±6 mm Hg. These indexes differed significantly from the analogous values obtained in 3 patients who died. The latter were as follows: TPR/SPR 0.67±0.29, PBF/SC 1.4±0.5, AV shunt 32±8%, and PPA postoperation 83±13 mm Hg. The results point to a marked variability of hemodynamic parameters at the 2nd-3rd H-E stages all the way to being the same as at the 3rd-4th stage. Since there was a fatal outcome independently of the morphological stage, the possibility of successful correction of CAT in such patients seems doubtful.

The findings lead to several conclusions. The hemodynamic parameters reflect the seriousness of lung-vascular changes and entirely determine the PPA dynamics postoperation. After radical correction of the defect, PPA remains elevated in all cases, and in 90% of cases it exceeds 50% of the systemic pressure, a fact that should determine the specifics of postoperative therapy for these patients. The criteria of operability of congenital heart defects with high PH defined in the H-E classification are not timely with regard to the feasibility of radical correction of CAT. At present the 3rd stage is the limit for surgical intervention.

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