

## Growth of the Pulmonary Arteries after Systemic-Pulmonary Shunt

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**Pulmonary artery growth after a systemic-pulmonary shunt was angiographically evaluated in 19 out of 35 patients. The mean age of the subjects at the time of the initial operation was  $18\pm 18$  months including 12 patients under a year old. The preoperative diagnosis was tetralogy of Fallot (TOF) in 10 patients, TOF plus pulmonary atresia in five and transposition of great arteries in four. A Blalock-Taussig shunt (BTS) operation was performed in 16 patients (15 classical and 1 modified) and a central shunt was performed in three patients as an initial operation. The preoperative pulmonary artery index (PAI) was  $129\pm 42$  in all patients and there were no significant differences between patients under or over a year old ( $139\pm 42$  vs.  $115\pm 49$ ). Postoperative angiography was performed  $32\pm 13$  months after the surgery. Room air arterial  $O_2$  pressure increased significantly from  $29\pm 5$  mmHg to  $42\pm 5$  mmHg just after an initial palliative shunt operation. PAI change in patients under a year old was  $214\pm 73\%$ , which was higher than  $145\pm 27\%$  in patients over a year old after a palliative shunt operation. On the ipsilateral side, PAI change was almost the same between patients under and over a year old. On the contralateral side, PAI change in patients under a year old was  $216\pm 68\%$ , which was significantly higher than the  $116\pm 21\%$  in patients over one year old. There was a significant negative correlation ( $r=-0.65$ ,  $p<0.05$ ) between PAI change and arterial  $O_2$  pressure as measured just after a palliative shunt operation. In conclusion, a palliative shunt operation prior to a year old is desirable in order to produce sufficient and bilateral pulmonary artery growth. (Ann Thorac Cardiovasc Surg 2001; 7: 337-40)**

**Key words:** pulmonary artery growth, systemic-pulmonary shunt, pulmonary artery index, tetralogy of Fallot

### Introduction

Primary corrections for infants with congenital complex heart diseases have been recently recommended.<sup>1)</sup> Some patients, however, require a palliative systemic-pulmonary shunt operation. We retrospectively studied the re-

lationship between patients' age and postoperative pulmonary artery growth with particular focus on the difference between the ipsilateral and the contralateral pulmonary arteries.

### Patients and Methods

A total number of 35 patients underwent a systemic-pulmonary shunt operation during a 14 year period beginning in 1984. Pulmonary artery growth after a systemic-pulmonary shunt was angiographically evaluated in 19 out of the 35 patients. Patients with a non-confluent pulmonary artery or major aorto-pulmonary collateral ar-

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**Table. Patients' characters and operations**

No. of patients	19		
Male / Female	16 / 3		
Mean age at operation	18 months (under 1 y/o: 12 pts, over 1 y/o: 7 pts)		
Diagnosis	Tetralogy of Fallot	10	
	Pulmonary atresia	5	
	TGA	4	
Body surface area	0.3 ± 0.1 m <sup>2</sup>		
Preoperative PAI	Total		
	129 ± 42 (under 1 y/o: 139 ± 42, over 1 y/o: 115 ± 49)		
Dominant site	right	leftv	equal
	Under 1 y/o	8	3
	Over 1 y/o	3	3
Operation	Operation		
Initial	Blalock-Taussig shunt: 16 (classical: 15, modified: 1)		
	Central shunt: 3		
Additional	Blalock-Taussig shunt: 1 (contralateral)		
	Central shunt: 3		
Follow-up period	32 ± 13 months		

Pts: patients, TGA: transposition of great arteries, PAI: pulmonary artery index, y/o: year old.

tery and those with insufficient shunt flow at the time of postoperative angiography were excluded from this study. The study group was composed of 16 males and three females. The mean age at the time of the initial operation was 18±18 months including 12 patients under a year old. The preoperative diagnosis was tetralogy of Fallot (TOF) in 10 patients, TOF plus pulmonary atresia (PA) in five and transposition of the great arteries (TGA) in four. Blalock-Taussig shunt (BTS) operation was performed in 16 patients (15 classical and 1 modified) and central shunt was performed in three patients as an initial operation. In the initial BTS procedure, the left subclavian artery was anastomosed to the left pulmonary artery with non-absorbable polypropylene sutures in all cases. Four patients required additional shunt operations; a central shunt in three patients and a contralateral BTS in one. Pulmonary artery growth was evaluated using the pulmonary artery index (PAI) advocated by Nakata and his colleagues.<sup>2)</sup> The PAI was calculated angiographically by the formula;

$$\text{PAI (mm}^2/\text{m}^2) = (\text{right pulmonary artery area} + \text{left pulmonary artery area}) / \text{body surface area}$$

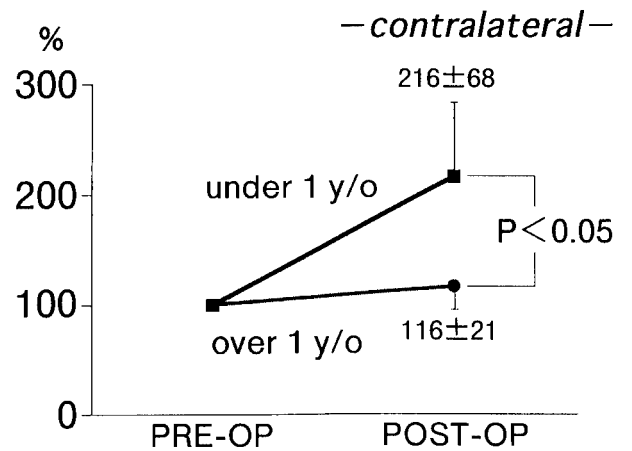
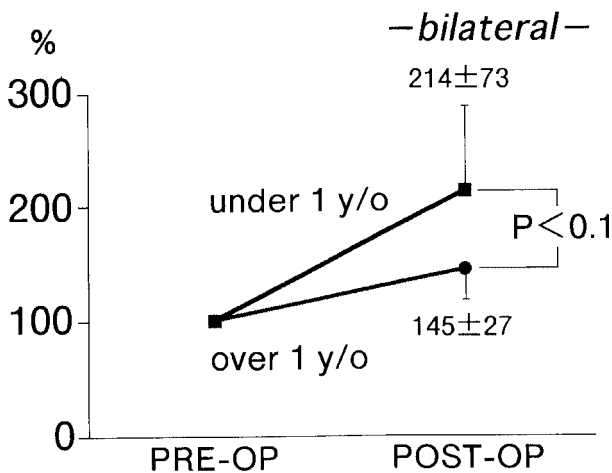
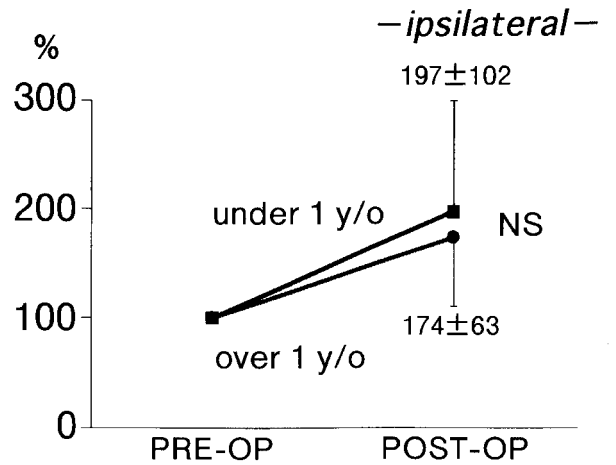
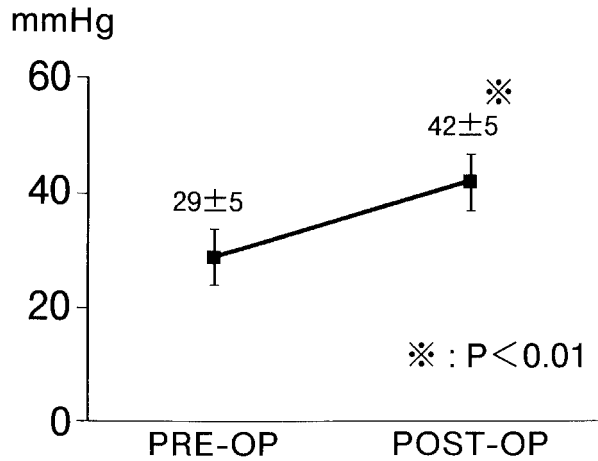
Preoperative PAI was 129±42 in total patients and there were no significant differences between patients under or over a year old (139±42 vs. 115±49, respectively). Preoperative PAI of patients under a year old was mostly dominant in the right side. Meanwhile the preoperative PAI of patients over a year old was similar on each side (Table). Postoperative pulmonary artery growth was

evaluated as the percentage of the postoperative to preoperative PAI. Postoperative angiography was performed 32±13 months after surgery.

Values are expressed as the mean ± standard deviation. The  $\chi^2$  test and the Student's t-test were used in the statistical analysis and a P value less than 0.05 was considered to be significant.

## Results

After an initial palliative shunt operation, room air arterial O<sub>2</sub> pressure increased significantly ( $p < 0.01$ ) from 29±5 mmHg to 42±5 mmHg. PAI change in patients under a year old was 214±73%, which was higher than the 145±27% in patients over a year old after a palliative shunt operation (Fig. 1). On the ipsilateral side, the PAI change was almost the same between patients under and over a year old. On the contralateral side, the PAI change in patients under a year old was 216±68%, which was significantly ( $p < 0.05$ ) higher than the 116±21% in patients over a year old (Fig. 2). PAI change after an additional shunt operation was 110±9%, which was ( $p < 0.1$ ) lower than the 190±66% after initial shunt operations. PAI change after an initial palliative shunt operation was 212±82% in TOF patients and 175±55% in non-TOF patients. There was a significantly negative correlation ( $r = -0.65$ ,  $p < 0.05$ ) between PAI change and arterial O<sub>2</sub> pressure as measured just after a palliative shunt operation (Fig. 3).



**Fig. 1.** Upper: preoperative and postoperative arterial O<sub>2</sub> pressure (mmHg), below: preoperative and postoperative pulmonary artery index.

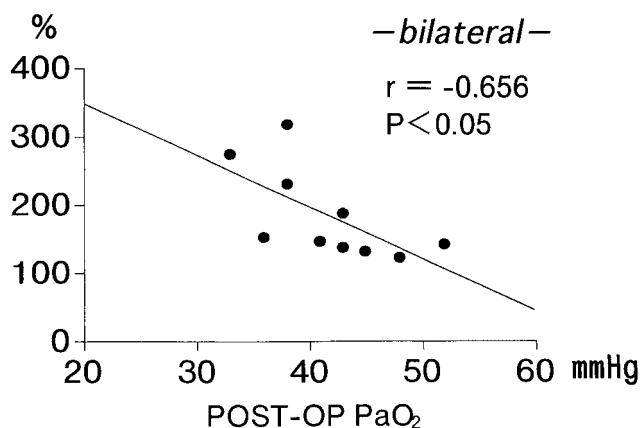
**Fig. 2.** Upper: preoperative and postoperative pulmonary artery index in the ipsilateral side, below: Preoperative and postoperative pulmonary artery index in the contralateral side.

## Discussion

The Blalock-Taussig shunt has been performed with low risk and is associated with excellent pulmonary artery growth.<sup>3)</sup> The trend in congenital heart surgery, however, is toward earlier and earlier correction, and in fact, most of the patients in this study would have been candidates for an earlier corrective operation today. Some patients, however, require a palliative systemic-pulmonary shunt operation. If palliation rather than primary correction is selected, the procedure should allow adequate development of the pulmonary arteries as well as improvement in oxygenation and general symptomatic status of patients. In our study, oxygenation improved significantly after the palliative shunt procedure. Kulkarni and his colleagues have reported that the left atrial systolic vol-

ume and left ventricular diastolic volume also increased significantly following the shunt procedure.<sup>4)</sup> The aim of this study was not to compare the outcome of a two-staged procedure as opposed to a single-staged procedure for complex congenital heart diseases. We studied the relationship between patients' age and postoperative pulmonary artery growth with a particular focus on the differences between the ipsilateral pulmonary and the contralateral arteries.

In cases of infants, significant growth of the main and bilateral pulmonary artery and pulmonary valve annulus have been obtained after both the classical and modified Blalock-Taussig shunt procedure.<sup>5,6)</sup> Pulmonary arterial growth is also similar on both the ipsilateral and contralateral side following a systemic-pulmonary shunt in infants.<sup>3)</sup> Honda and his colleagues reported that the PAI



**Fig. 3.** Relationship between postoperative O<sub>2</sub> pressure and pulmonary artery index.

change was higher in patients under six months of age than in older patients.<sup>7)</sup> In this study, the PAI change in patients under a year old was slightly higher than that in patients over a year old following the palliative shunt operation. In particular, the growth of the contralateral pulmonary artery was significantly less in older patients than in younger patients. On the ipsilateral side of the shunt procedure, pulmonary arterial flow is mainly supplied via the shunt. Venous blood flows into the contralateral pulmonary artery via the narrow main pulmonary artery. The PAI change demonstrated a significant negative correlation with arterial O<sub>2</sub> pressure, as measured just after the palliative shunt operation in this study. Thus, O<sub>2</sub> content itself does not appear to influence pulmonary artery growth after a shunt procedure. Pulmonary artery growth on the contralateral side, however, was less in patients over a year old. We believe that pulmonary artery growth depends on latent growth ability, which is more significant in patients under a year old than in those

over a year old. We suspect that the difference of blood flow and O<sub>2</sub> content between the ipsilateral and contralateral side influenced pulmonary artery growth in older patients. In conclusion, the palliative shunt operation before the child turns one is desirable in order to promote a sufficient and bilateral pulmonary artery growth.

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