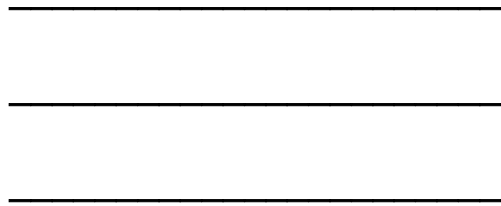


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2002 6



CT

	-----	1
I.	-----	4
II.	-----	7
1.	-----	7
2.	(pulmonary artery/vein ratio) - -	8
3.	- -----	9
4.	-----	14
III.	-----	15
IV.	-----	23
V.	-----	29
	-----	30
	-----	36

1. Hypertrophied bronchial artery - - - - -	11
2. Hypertrophied intercostal artery in a 21 - year old female with TOF and right pulmonary arterial hypoplasia - - - - -	12
3. Hypertrophied internal mammary artery in a 30 - year old male with TOF - - - - -	13
4. PA/PV distribution of control and patient group - - - - -	16
5. Relationship between PA/PV ratio and cross - sectional area of each type of collateral artery - - - - -	20
6. Relationship between PA/PV ratio and sum of cross sectional area of total collateral arteries observed at each lung - - - - -	22

1. Difference of PA/PV ratio between the patient group and the normal control group (Mann - Whitney U test) - - - - -	15
2. Difference of PA/PV ratio between patients with and without collateral arteries for the each types of collateral artery (Mann - Whitney U test) - - - - -	18
3. Difference of PA/PV ratio in terms of total numbers of collateral arteries - - - - -	19

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CT

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CT

11 (4 4 ,

4 ,

1 , 24.6)

가

22 (18.9)

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, [] - [2]

. 가

CT

가 - 가 .

0.65±0.13, 0.71

± 0.13 . 0.52

0.58 , 22 15 (10 [0.23 ±

0.16], 5 [0.25 ± 0.19]) 가 .

9 (3.1 - 38.5mm²), 11 (3.1 -

17.3mm²), 9 (7.1 - 19.7mm²)

, 가 15 ,

7

. (0.20 ± 0.10)

(0.78 ± 0.25) 가

(p=0.000).

가 (; r = - 0.639, p=0.001,

; r = - 0.724, p=0.000, ; r = - 0.475, p=0.026),

가 (r = - 0.864, p=0.000).

, 가 CT

- ,

가 , -

CT

가



: , , , , ,

가

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I.

가

- (systemic - to - pulmonary collateral circulation) .¹

,

,

.²

.

가 가 ,

가 (rewarming)

가 ,

가 가 , , ,

, 가 -

가 가 .³

- ,

CT가 가 .

II.

1.

1991 1999 CT
11 (5 , 6) ,
14 57 24.6 .
4 6 (2 Blalock - Taussig[BT] , 1
) ,
(pulmonary atresia) 4 (BT) ,
1 .
CT , CT 5 - 10mm GE 9800 Quick
scanner (GE Medical System, Milwaukee, Wisconsin) 3 - 8mm
Imatron XP - 150 (Imatron Inc., San Fransico, CA, USA) ,
9 CT 가 .
(post - stenotic dilatation) , major aorto - pulmonary
collateral artery , -
(cavopummonary connection)
,
. , CT
가 22 (12 , 10 , 18.9 [1 - 39])
, CT , CT

5 - 8mm Imatron XP - 150 (Imatron Inc., San Francisco, CA, USA) .

2. (pulmonary artery/vein ratio)

(truncus anterior)

,
 , BT
 .
 . 가
 가
 ,
 ()
 .
 = *(/2)^2/ *([/2]^2 + [/2]^2)
 , 가 - 가
 가 , [- 2
] -

3. -

- ,
CT 3가 , ,
.

(1)
, CT

2mm (1A).¹²

가 .

가

(1B).

(2) ,

가 ,

(3)

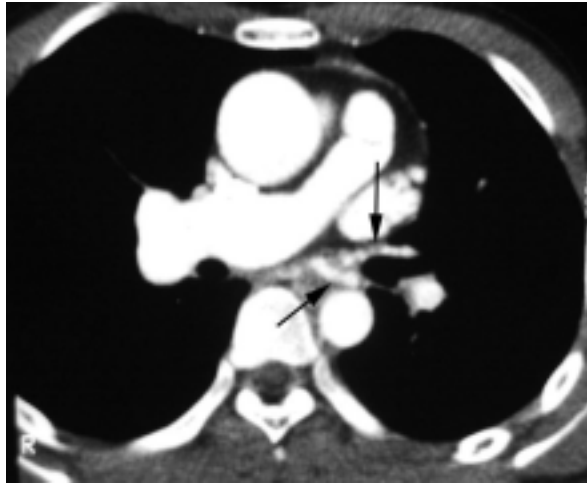
3mm ¹²

가 CT

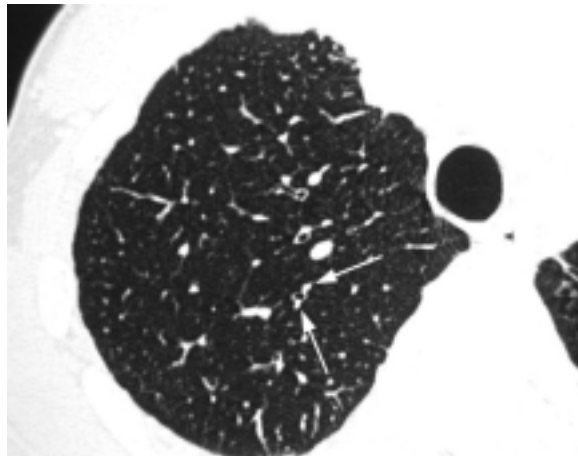
2

(S.J.Ryu, B.W.Choi)가

가

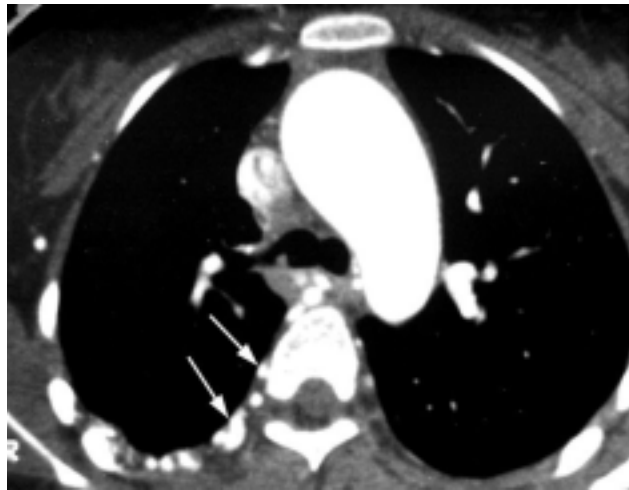


(A)

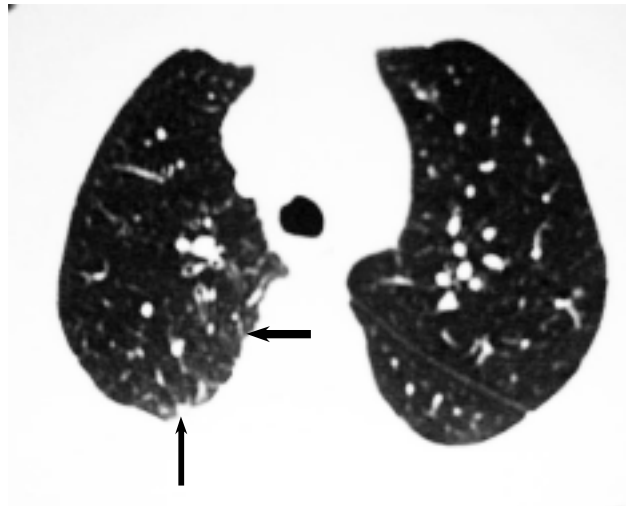


(B)

1. Hypertrophied bronchial artery. (A). TOF with left pulmonary arterial interruption in a 16 - year old male. A hypertrophied bronchial artery can be seen in the mediastinum (arrows). The origin from descending thoracic aorta and course in mediastinum to the left hilum is well demonstrated. (B). Another patient with pulmonary atresia showing hypertrophied bronchial artery in the lung parenchyma. One bronchus accompanies by two arteries (arrows). The one is enlarged bronchial artery and the other is pulmonary artery.



(A)

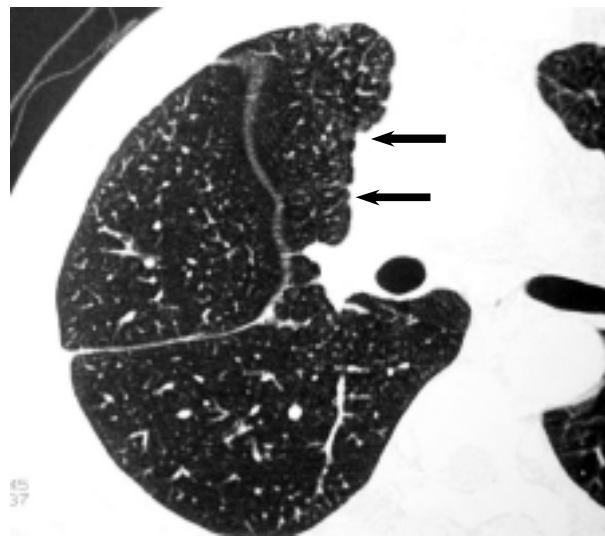


(B)

2. Hypertrophied intercostal artery in a 21 - year old female with TOF and right pulmonary arterial hypoplasia. (A). A hypertrophied intercostal artery is noted as well-enhancing serpiginous vascular structure at intercostal space (arrows). (B). The linear branching structures are connected into lung parenchyma (arrows).



(A)



(B)

3. Hypertrophied internal mammary artery in a 30 - year old male with TOF. (A). Bilateral internal mammary arteries are hypertrophied (arrows) and multiple enhancing vascular structures at anterior mediastinum (arrowheads) can be noted. (B). The transpleural connection of collaterals at anterior mediastinum is well - demonstrated (arrows).

4.

가

Mann - Whitney U test

, ,
0.05
가 ,
가 0.4 , 0.41 0.75
, 0.75 .

III.

144 ± 61mm², 217 ± 72mm², 142 ± 54mm²,
198 ± 61mm²

0.65±0.13 (0.42 - 0.89), 0.71 ± 0.13 (0.50 - 1.02),

0.68±0.13 (0.42 - 1.02) .

0.28 ± 0.19 (0.11 - 0.77), 0.60 ± 0.38 (0.00 - 1.22) ,

0.44 ± 0.34 (0.00 - 1.22) (4).

가

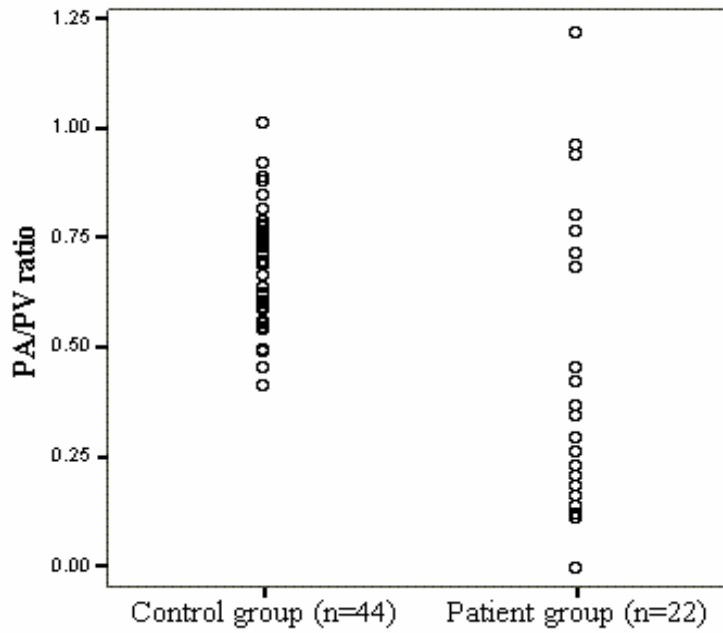
, 가 가

가 가 가 .

, 가 (1).

1. Difference of PA/PV ratio between the patient group and the normal control group (Mann - Whitney U test).

PA/PV Ratio	Patients Group (n=11)	Control Group (n=22)	p - value
Right	0.28±0.19 (0.11 - 0.77)	0.65±0.13 (0.42 - 0.89)	0.000
Left	0.60±0.34 (0.00 - 1.22)	0.71±0.13 (0.50 - 1.02)	0.211
Total	0.44±0.34 (0.00 - 1.22)	0.68±0.13 (0.42 - 1.02)	0.000



4. PA/PV distribution of control and patient group. The PA/PV ratio range of patient group is wider than that of control group due to significant asymmetry of pulmonary arterial blood flow between bilateral lungs in patient group. n means number of total lungs.

(
-2) 0.52, 0.58,
0.55 . 11 22
15 , 가 10 (0.23 ± 0.16, 0.11 - 0.37)
, 가 5 (0.25 ± 0.19, 0.00 - 0.46) ,
0.24 (± 0.13, 0.00 - 0.46) . 11

가 4 .

가 15 , 9 (60%)

1

2 , 3.1mm² 38.5mm² .

11 (73%) , 5 ,

3.1mm² 17.3mm² . 9 (60%)

7.1mm² 19.7mm²

. 가 15 , 2

1 , 3 2 , 2 3

, 2 4 , 1 5 , 3

7 , 2

0.42 0.46 가

가 . 22

7 .

13 (0.20 ± 0.10, 0.00 - 0.37)

9 (0.78 ± 0.25, 0.42 - 1.22)

가 (Mann - Whitney U test, p=0.000),

가 (2).

2. Difference of PA/PV ratio between patients with and without collateral arteries for the each types of collateral artery (Mann - Whitney U test).

Type (criteria of enlargement)	Enlarged (n)	Non - enlarged (n)	p - value
Bronchial artery ($\phi \geq 2\text{mm}$)	0.20 \pm 0.12 (9)	0.59 \pm 0.34 (13)	0.003
Intercostal artery (if visible)	0.19 \pm 0.11 (11)	0.68 \pm 0.31 (11)	0.000
Internal mammary artery ($\phi \geq 3\text{mm}$)	0.19 \pm 0.11 (9)	0.60 \pm 0.34 (13)	0.003

($r = -0.374$),

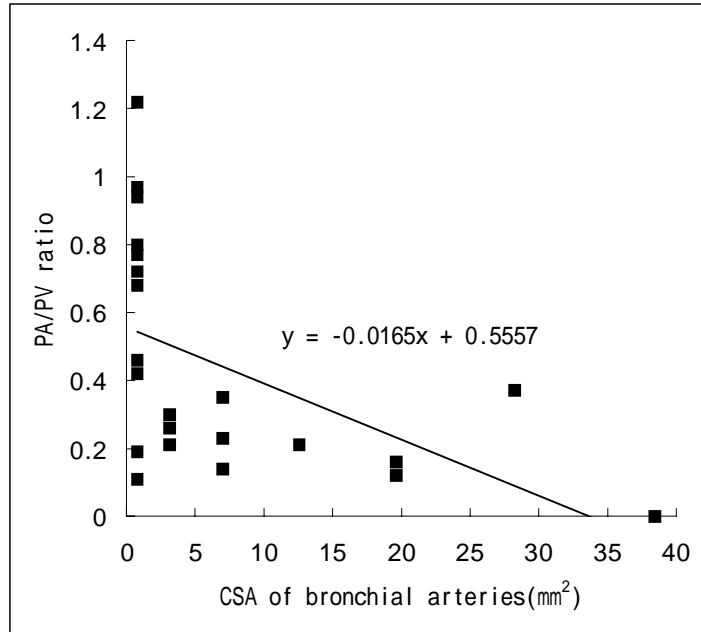
가 ($p = 0.208$) (3).

3. Difference of PA/PV ratio in terms of total numbers of collateral arteries.

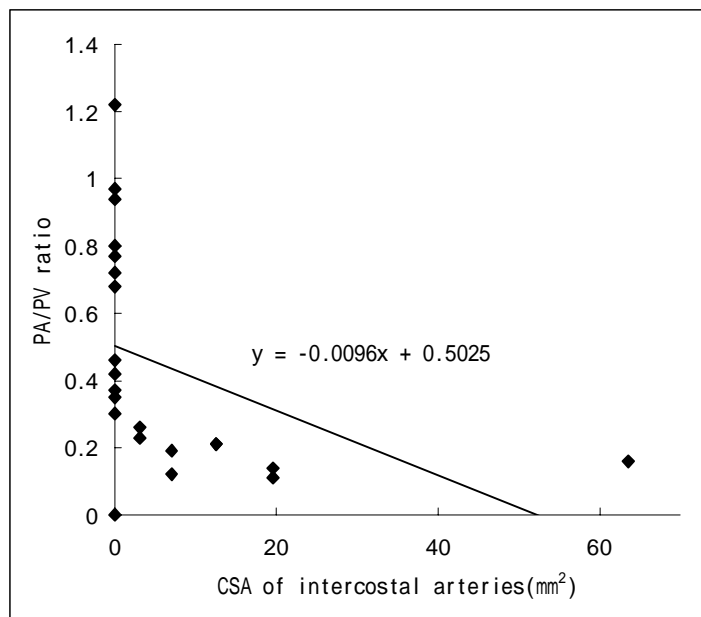
The mean PA/PV ratio in patients without collateral arteries is significantly higher than patients with collateral arteries ($p=0.000$, all). However, there was no difference in mean PA/PV ratio between numbers of collateral arteries ($p>0.05$, all) (* the case excluded from the statistical analysis). (ANOVA test)

Numbers of collateral arteries	PA/PV Ratio
0 (n=9)	0.78±0.25
1 (n=2)	0.27±0.04
2 (n=3)	0.24±0.11
3 (n=2)	0.16±0.07
4 (n=2)	0.18±0.26
5 (n=1)*	0.14
7 (n=3)	0.18±0.02

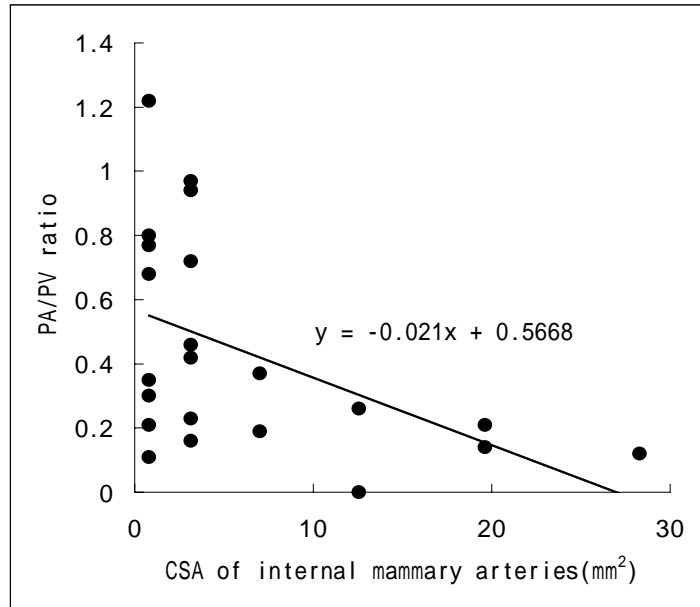
($r = -0.639$,
 $p = 0.001$), ($r = -0.724$, $p = 0.000$), ($r = -0.475$, $p = 0.026$)
 (5).



(A)



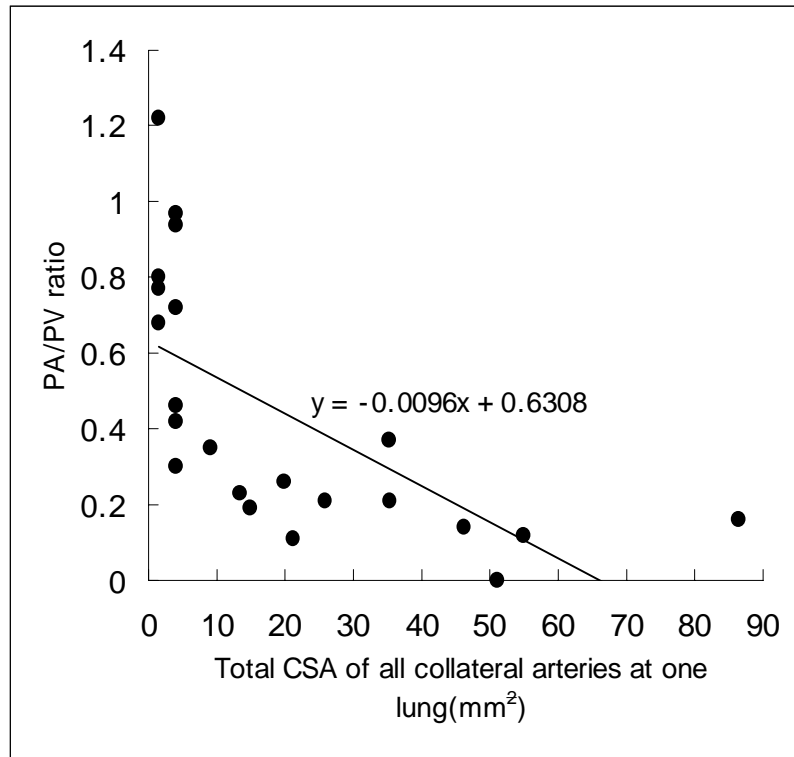
(B)



(C)

5. Relationship between PA/PV ratio and cross - sectional area of each type of collateral artery. As PA/PV ratio decreases, the cross - sectional area of each type of collateral arteries tends to increase, showing good correlation coefficient (linear regression analysis). (A) Bronchial artery ($r = -0.639$, $p = 0.001$), (B) intercostal artery ($r = -0.724$, $p = 0.000$), and (C) internal mammary artery ($r = -0.475$, $p = 0.026$), respectively.

가 ($r = -0.864$, $p = 0.000$) (6).



6. Relationship between PA/PV ratio and sum of cross - sectional area of total collateral arteries observed at each lung. As PA/PV ratio decreases, the sum of cross-sectional area of collateral arteries is increased, showing excellent correlation coefficient ($r = -0.864$, $p = 0.000$, linear regression analysis).

IV.

- , 가가 .13 -
(oximetry)

indocyanin green
- ,14

(cross - clamping)
15,16 ,

가 (cardiopulmonary bypass)

, - ,

.17

가 가

.5

CT, ,

6-8

가

18

가

13,19

가

20,21

22

가

(microsphere)

30%

.²³ ,
 ,
 (transpleural anastomosis) .²⁰
 4 -
 ,
 가 가 ,
 .²⁴ - (total cavopulmonary
 connection, TCPC)
 - 가 ,¹³
 45% .¹⁶ ,
 -
 .
 15 9 (60%)
 ,
 가 11 (73%)
 .
 , 가
 가 .²⁵ 가
 ,
 가 가 . CT
 가 (pseudofibrosis) 가
 ,

가

26

13

가

가

27

가

angiopietin - 1 가

28

CT

CT

11,29

, CT

가

29,30

CT

25, 31

가

CT

가

가

21

(velocity - encoded cine MR)

가

32,33

34

가 가

가

가

CT

, CT가

13

x

(beam hardening

artifact)

가 가

, CT

가 .

X

가 .

V.

CT - ,
가

가

CT - ,

가 .

- ,

- 가 . 가

CT

가 .

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Abstract

**Pulmonary artery - vein ratio by computed tomography in
congenital
heart disease with decreased pulmonary blood flow**

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The Graduate School, Yonsei University

(Directed by Professor **Kyu Ok Choe**)

In congenital heart disease (CHD) with decreased pulmonary blood flow (PBF), various systemic-to-pulmonary collateral (SPC) blood flow develop to compensate decreased PBF. Measurement of the SPC is useful for determination of preoperative embolization and predict immediate postoperative or long-term prognosis, but quantification is difficult. This study is designed to evaluate the relation between SPC blood flow and PBF decrease, manifesting as discrepancy in dimension of pulmonary artery (PA) and pulmonary vein (PV), in CHD patients with decreased PBF, using contrast-enhanced computed tomography (CT).

11 patients with CHD (6 tetralogy of Fallot, 4 pulmonary atresia

with ventricular septal defect and 1 congenital interruption of right interlobar pulmonary artery, mean age 26.4 years) and 22 age-matched healthy persons as normal control (mean age 18.9 years) were undergone contrast-enhanced CT. The cross-sectional area (CSA) ratio of PA/PV (PA/PV ratio) for each lung in both the patient and the control group was calculated. The value below (mean PA/PV ratio - 2SD) obtained from control group was considered as criteria of decreased PBF in patient group. The numbers and CSA of SPC arteries including bronchial, intercostal and internal mammary artery, which supply unilateral lung, were recorded at patient group using CT. We compared the PA/PV ratio with numbers and CSA of SPC arteries and evaluated the relation between PA/PV ratio and SPC blood flow in patient group.

The PA/PV ratio in normal control group was 0.65 ± 0.13 at the right lung and 0.71 ± 0.13 at the left lung. The value below 0.52 at the right lung and 0.58 at the left lung was determined as criteria of decreased PBF in patient group. 15 lungs (10 right lungs [0.23 ± 0.16], 5 left lungs [0.25 ± 0.19]) of total 22 lung in the patient group were fulfilled the criteria. Of these 15 lungs, hypertrophied collateral arteries were found as follows; bronchial arteries ($3.1 - 38.5 \text{mm}^2$) at 9 lungs, intercostals arteries ($3.1 - 17.3 \text{mm}^2$) at 11 lungs and internal mammary arteries ($7.1 - 19.7 \text{mm}^2$) at 9 lungs, respectively. Any collateral arteries were not found in all 7 lungs which showed normal

range of PA/PV ratio in patient group. The PA/PV ratio between patients with collateral arteries (0.20 ± 0.10) and without those (0.78 ± 0.25) was significantly different ($p=0.000$). Good reciprocal relationship between the PA/PV ratio and CSA of hypertrophied collateral arteries was demonstrated as follows; bronchial artery ($r= -0.639$, $p=0.001$), intercostal artery ($r= -0.724$, $p=0.000$) and internal mammary artery ($r= -0.475$, $p=0.026$), respectively. Furthermore, excellent reciprocal relationship between the PA/PV ratio and sum of CSA of hypertrophied collateral arteries at one lung is demonstrated ($r= -0.864$, $p=0.000$).

In conclusion, contrast-enhanced CT could successfully demonstrate SPC arteries, which were found only in the lungs with decreased PBF manifesting as PA/PV ratio below normal value. Also, excellent reciprocal relationship between PA/PV ratio and CSA of SPC arteries could make it possible to semi-quantitatively estimate SPC blood flow by measurement of PA/PV ratio.

Key Words: congenital heart disease, pulmonary blood flow, pulmonary imaging, pulmonary vessels, collateral vessels, computed tomography