Glenn procedure with additional flow enlarges pulmonary size without extra cardiac-stress

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【 Background 】

We often leave additional flow to pulmonary arteries in Glenn procedure to grow pulmonary artery larger.

However, additional flow (ADF) is suggestive of imposing over-loads against mono- ventricular circulation.

【 Objecive 】

We investigated cardiac function and pulmonary circulation in Glenn patients with additional flow (ADF).

【 Methods】

・The medical records of 73 Glenn patients were reviewed who were confirmed additional flow (ADF) on cardiac catheterization.

・Control was 53 Glenn patients who were not confirmed ADF. They all underwent cardiac catheterization between 2010 and 2017.

・We compared cardiac performances and pulmonary circulation indexes between Glenn patients with and without ADF.

Additional flow to pulmonary artery (PA) was reserved by following methods, such as

Conduit from right ventricle to PA (**RV-PA: 29**),

Shunting from aortic branch (**BT:13**),

Antegrade flow from ventricular outflow tract

(**PA banding/ Native Pulmonary Stenosis: 30**).

All additional flows were lessened by narrowing their tracts.

Comparison of clinical characteristics between Glenn patients with and without additional flow (ADF)

	ADF (n=72)	Non-ADF (n=54)	p value
Study age (yrs)	**1.7±0.5**	**1.9±0.8**	**0.075**
Glenn age (yrs)	**0.8±0.5**	**1.0±0.6**	**0.078**

Study ages and Glenn ages were not different between patients with and without ADF.

	ADF (n=72)	Non-ADF (n=54)	p value
Right isomerism (%)	**13/72 (18)**	**6/54 (11)**	**0.71**
Ventriclular type (n)	**R (29) L (12) B (31)**	**R (20) L (18) B (16)**	**0.075**

Frequencies of right isomerism heart were not different between two groups.

The ratios of ventricular types, which were divided into 3 types (single right ventricle**: R**, single left ventricle**: L**, and bi-ventricle**: B**), were not significantly different between two groups.

	ADF (n=72)	Non-ADF (n=54)	p value
1st strategy (n)	Shunt (22) PAB/NPS (14/13) Norwood (23)	Shunt (22) PAB/NPS (19/1) Norwood (12)	0.89
AVV repair (%)	10/72 (13)	4/54 (7)	0.39

Shunt: shunting from aortic branch to pulmonary artery

PAB/NPS: pulmonary trunk banding or native pulmonary stenosis

Norwood: Norwood procedure with shunting to pulmonary artery

First strategies before Glenn, which were divided into 3 categories mainly by type of pulmonary artery and presence or absence of obstruction for major ventricle outflow, were not different between two groups.

Frequencies of atrio-ventricular valve repair (AVV repair) were not significantly different between two groups.

	ADF (n=72)	Non-ADF (n=54)	p value
AVVR ≥ II	**18/72 (25)**	**7/54 (12)**	**0.14**
NT-proBNP (pg/ml)	**836±1327**	**534±683**	**0.17**

Strong regurgitation of atrio-ventricular valve (**AVVR ≥ II)** subsisted at the similar rate between two groups.

The levels of NT-pro BNP were not significantly different between two groups.

Pulmonary circulation factors in Glenn patients with ADF

	ADF (n=72)	Non-ADF (n=54)	P value
Qp (L/min/m2)	3.8±1.0	2.8±0.6	<0.0001

Qp (L/min/m2): pulmonary flow

We compared pulmonary circulation factors between ADF group and non-ADF group.

Pulmonary flows (**Qp**) were significantly more in ADF patients than in non-ADF patients.

	ADF (n=72)	Non-ADF (n=54)	P value
PAI (mm2/m2)	276±131	224± 94	0.023
LPA (mm/m2)	18.3±5.7	16.3± 4.2	0.034
RPA (mm/m2)	20.9±5.2	18.2± 4.2	0.025

PAI (mm2/m2): Nakata index

LPA (mm/m2): diameters of left pulmonary artery

RPA (mm/m2): diameters of right pulmonary artery

Accordingly, pulmonary indexes (**PAI**) were larger in ADF group; right and left pulmonary arteries were larger respectively in ADF group.

	ADF (n=72)	Non-ADF (n=54)	P value
SVCP (mmHg)	13.9±3.9	12.3±4.0	0.039
LAP/PCWP (mmHg)	8.3±3.3	7.9±3.3	0.46
Rp (U*m2)	1.6±0.8	2.0±0.86	0.014
AoSatO2 (%)	85±4	84±5	0.33

SVCP: pressures of superior vena cava

LAP/PCWP: left atrium pressures or pressures of pulmonary capillaly wedge

Rp: pulmonary resistances

AoSatO2: oxygen saturation of aorta

Pressures of superior vena cava (**SVCP**) were significantly elevated in ADF patients. Pulmonary resistances (**Rp**)were also elevated in ADF patients.

Cardiac performances in Glenn patients with ADF

	ADF (n=72)	Non-ADF (n=54)	P value
SVEDV (%)	180±65	167±66	0.27
SVESV (%)	82±47	76±45	0.46
SVEF (%)	57±9	55±10	0.42

SVEDV: ventricular volumes on end-diastole

SVESV: ventricular volumes on end-systole

SVEF: ejection fraction of systemic ventricle

Cotnrary to our expectance, ventricular volumes on end-diastole (**SVEDV**) and on end-systole (**SVESV**) were not significantly different between patients with and without ADF.

Accordingly, ventricular ejection fractions (**SVEF**) were not significantly different between two groups.

	ADF (n=72)	Non-ADF (n=54)	P value
SVEDP (mmHg)	**10.0±2.9**	**9.4±3.2**	**0.34**
SVESP (mmHg)	**80±10**	**83±21**	**0.29**
aAo syst (mmHg)	**76±9**	**76±8**	**0.79**

SVEDP: ventricular pressures on end-diastole

SVESP: ventricular pressures on end-systole

aAo syst: systolic pressures of aorta

As to pressure study, end-diastolic ventricular pressures (**SVEDP**) were not significantly different between two groups.

Systemic pressures (**aAosyst**) were also not different.

	ADF (n=72)	Non-ADF (n=54)	P value
Qs (L/min/m2)	4.5±1.1	4.7±1.2	0.29
Qp/Qs	0.86±0.27	0.63±0.16	<0.0001

Qs: cardiac output

Qp/Qs: the ratio of pulmonary flow to systemic flow

. Based on these data, cardiac output (**Qs**) was not significantly different between ADF group and non-ADF group.

However, the ratio of pulmonary flow to systemic flow (**Qp/Qs**) was increased in ADF patients.

Major findings.

First, additional flow to pulmonary (ADF) artery grew pulmonary artery diameters larger in Glenn patients.

Second, cardiac functions were not depressed in Glenn patients with additional flow (ADF).

Pulmonary circulation in patients with ADF.

Our study showed additional flow to pulmonary artery (ADF) enlarged pulmonary artery size in Glenn patients.

We assumed pulmonary arteries got larger by means of ADF in Glenn patients.

In compensation for growth of pulmonary arteries, Glenn patients with ADF owned mildly elevated pressures of superior vena cava and mildly elevated pulmonary resistances.

We considered that these levels of elevation did impede Fontan circulation, if we remove ADF on procedure.

Cardiac performances in patients with ADF.

Contrary to our expectance, ventricular volumes in Glenn patients with additional flow (ADF) were not larger those in non-ADF patients, such as systemic ventricular volumes on end-diastole and on end-systole.

To fear pulmonary high flow as much as producing cardiac hypofunction, we lessened all ADF by narrowing their tracts.

So ventricular expansion would not appear in this study.

Conclusion.

Additional flow to PA left in Glenn patients could turn out a good strategy to grow PA without excess cardiac loads.

We could make additional flow coexisting in Glenn patients without depressing cardiac functions.