Evaluation of tissue oxygen delivery after Fontan operation:
Flow quantification with MRI

공지사항

- 소속기관이나 저자명이 드러나지 않도록 해주세요.
- 제목 슬라이드 포함 최대 6장, Font size 20 이상
- **PPT 파일 작성 후 PDF로 전환해서 접수(필수)**

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Purpose

- Fontan operation
  - Palliative surgery for the patients with functionally single ventricle
- Post-Fontan physiology
  - Suboptimal cardiac output
  - Hypoxia associated with
    - Collateral vessels
    - Formation of fenestration upon Fontan operation
- This study sought to evaluate cardiac output and estimated tissue oxygen delivery by magnetic resonance imaging (MRI) in post-Fontan physiology

- Single center retrospective study
- Inclusion
  - Patients who underwent Fontan operation between Jan 2008 and Aug 2022 (N=251)
- Exclusion
  - Lack of post-Fontan MRI scan (N=76)
- Study population: 175 patients
- Fenestration
  - Elective fenestrated Fontan operation in the high-risk patients
  - Additive fenestration for hemodynamically unstable patients after Fontan operation
  - Routine elective fenestrated Fontan operation: surgeon's preference
- Perfusion and oxygen delivery calculation
  - Cardiac output: sum of flow through SVC and descending thoracic aorta
  - $DO_2I = O_2$ delivery index = DO_2 mls/min/m² = $(10 \times Hb/dl \times 1.34 \times SpO_2) + (PaO_2$ in mmHg $\times 0.003 \times 10) \times$ Cardiac index l/min/m².

- Baseline characteristics

	Overall (N=175)	Non-fenestrated Fontan (N=118)	Fenestrated Fontan (N=57)	P
Male sex (%)	105 (60)	70 (59%)	35 (61%)	0.92
Right dominant ventricle (%)	60 (34)	36 (31%)	24 (42%)	0.18
Pre-Fontan cath data (mean ± SD)				
Nakata index (mm²/m², mean ± SD)	353 ± 135	363 ± 139	332 ± 125	0.15
Mean PA pressure (mmHg)	8.9 ± 3.7	8.6 ± 3.3	9.8 ± 4.3	0.045
Qp/Qs	0.7 ± 0.3	0.8 ± 0.3	0.7 ± 0.3	0.54
Pulmonary vascular resistance (wu)	1.3 ± 0.7	1.3 ± 0.7	1.4 ± 0.7	0.19
Transpulmonary gradient (mmHg)	4.3 ± 2.2	4.2 ± 2.0	4.5 ± 2.5	0.51
LVEDP (mmHg)	6.7 ± 3.9	6.4 ± 4.0	7.4 ± 3.7	0.12
TTE data (%)				
Ventricular dysfunction (EF < 50%)	19 (11%)	12 (10%)	7 (12%)	0.87
AVVR > moderate	10 (6%)	6 (5%)	4 (7%)	0.87
Age at Fontan (Y, mean ± SD)	3.3 ± 1.2	3.3 ± 1.5	3.3 ± 0.6	0.93
Weight at Fontan (kg, mean ± SD)	14.4 ± 7.8	14.6 ± 9.4	14.0 ± 1.7	0.67
Fenestration timing (%)				
No fenestration	118 (67%)			
Elective fenestration	47 (27%)		47 (83%)	
Additive fenestration	10 (6%)		10 (18%)	
ICU stay (days, mean ± SD)	4.8 ± 5.3	3.7 ± 3.3	7.1 ± 7.6	<0.001
Hospital stay (days, mean ± SD)	27.7 ± 19.7	24.8 ± 16.6	33.7 ± 24.0	0.005

- MRI findings

	Overall (N=175)	Non-fenestrated Fontan (N=118)	Fenestrated Fontan (N=57)	P
Age at MRI (Y, mean ± SD)	3.6 ± 1.2	3.6 ± 1.5	3.6 ± 0.6	0.89
SpO2 at MRI (%, mean ± SD)	93.7 ± 4.9	95.9 ± 2.4	89.2 ± 5.7	<0.001
Hb at MRI (g/dL, mean (SD))	12.6 ± 1.4	12.6 ± 1.2	12.6 ± 1.64	0.96
MRI findings				
Heart rate (mean (SD))	102 ± 14	100 ± 14	106 ± 12	0.010
Flow in ascending aorta (L/min, mean ± SD)	2.8 ± 2.5	2.8 ± 3.0	2.8 ± 0.6	0.87
Flow in descending aorta (L/min, mean ± SD)	1.0 ± 0.2	0.9 ± 0.2	1.0 ± 0.2	0.20
Flow in SVC (L/min, mean ± SD)	1.0 ± 0.3	1.0 ± 0.3	1.0 ± 0.2	0.15
Flow in Fontan conduit (L/min, mean ± SD)	0.7 ± 0.8	0.8 ± 0.9	0.6 ± 0.3	0.12
Calculated outcomes				
Stroke volume (L/min/m², mean ± SD)	20 ± 4.3	20 ± 4.8	19 ± 3.1	0.15
Cardiac index (L/min/m², mean ± SD)	3.2 ± 0.6	3.2 ± 0.7	3.2 ± 0.5	0.90
Oxygen content (mlO₂/L, mean ± SD)	161 ± 18	165 ± 17	152 ± 19	<0.001
Oxygen delivery (mlO₂/min, mean ± SD)	315 ± 76	325 ± 84	295 ± 50	0.014
Indexed oxygen delivery (mlO₂/min/m², mean ± SD)	511 ± 109	525 ± 117	481 ± 84	0.012

- Multivariable linear regression analysis for indexed oxygen delivery
  - Right dominant ventricle (∂=-48, P<0.001), Nakata index (∂=0.24, P<0.001) were associated with indexed oxygen delivery, while fenestration (∂=-30, P=0.061) was not significantly associated

- The majority of post-Fontan patients would have hemodynamic parameters comparable to those of healthy populations.

- There was no significant difference in terms of stroke volume and cardiac index between fenestrated and non-fenestrated Fontan operation.

- In addition, patients with fenestrated Fontan can be associated with decreased oxygen content and tissue oxygen delivery, however, these findings could be the result of suboptimal characteristics such as ventricular morphology and pulmonary arterial status.