PERFUSION METHODS AND MODIFICATIONS TO THE CARDIOPULMONARY BYPASS CIRCUIT FOR MIDLINE UNIFOCALIZATION PROCEDURES

Tristan D. Margetson CCP, FPP, Justin Sleasman, CCP, FPP, Sami Kollmann, CCP, Patrick J. McCarthy CCP, Ozzie Jahadi CCP, Don Sheff CCP, Paul Shuttleworth RN, CCP, Richard D. Mainwaring MD, and Frank L. Hanley MD

Lucile Packard Children's Hospital

Stanford University School of Medicine

Amsect Pediatric Conference October 4th to October 6th 2018, Miami Florida

Disclosures

The authors have no disclosures

Introduction (I)

Pulmonary atresia with ventricular septal defect and major aortopulmonary collateral arteries (PA/VSD/MAPCAs) is a relatively rare and complex form of congenital heart disease

This entity is characterized by all of the pulmonary blood flow originating from the aorta or other systemic arteries (MAPCAs), since there is pulmonary atresia and no ductus arteriosus

The anatomy of MAPCAs is a recapitulation of early embryologic pulmonary circulation in humans

Introduction (II)

The surgical repair of PA/VSD/MAPCAs requires harvesting of the MAPCAs from their systemic source

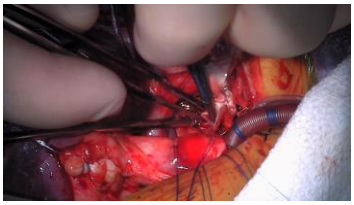
The MAPCAs are then brought together surgically (a process known as "unifocalization") to create a centralized pulmonary arterial bed

The VSD can then be closed and the right ventricle connected to the unifocalized MAPCAs by a conduit to complete the repair

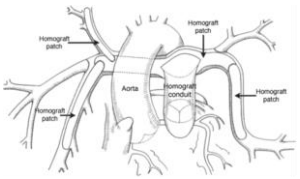
Purpose

These are complex and very lengthy procedures that require an entirely different method of perfusion

The purpose of this study was to review our perfusion modifications to support these unifocalization procedures



Complete Surgical Repair



Stanford Children's Health

STANFORD SCHOOL OF MEDICINE
Stanford University Medical Center

CONGENITAL: PULMONARY ATRESIA VENTRICULAR SEPTAL DEFECT AND AORTOPULMONARY COLLATERALS

Surgical algorithm and results for repair of pulmonary atresia with ventricular septal defect and major aortopulmonary collaterals

Richard D. Mainwaring, MD,[a] William L. Patrick, MD,[a] Stephen J. Roth, MD, MPH,[b] Komal Kamra, MD,[c] Lisa Wise-Faberowski, MD,[c] Michal Palmon, BS, MPH,[a] and Frank L. Hanley, MD[a]

ABSTRACT

Objective: Pulmonary atresia with ventricular septal defect and major aortopulmonary collateral arteries is a complex and heterogeneous form of congenital heart disease. There is a controversy regarding the optimal treatment of pulmonary atresia with ventricular septal defect and major aortopulmonary collateral arteries. The purpose of this study was to summarize our algorithm and surgical results for pulmonary atresia with ventricular septal defect and major aortopulmonary collateral arteries.

(J Thorac Cardiovasc Surg 2018;156:1194-204)

Stanford Children's Health

STANFORD SCHOOL OF MEDICINE
Stanford University Medical Center

Methods (I)

64 unifocalizations have been performed at our institution during the past 3 years

The median age at surgery was 4.1 months (range 1 month to 3.5 years)

The median weight was 4.5kg (range 3.5 to 19kg)

Stanford Children's Health

STANFORD SCHOOL OF MEDICINE
Stanford University Medical Center

Methods (II)

The median duration of cardiopulmonary bypass was 352 minutes (range 128 to 629 minutes)

The median duration of cross clamp was 24 minutes (range 14 to 72 minutes)

Stanford Children's Health

STANFORD SCHOOL OF MEDICINE
Stanford University Medical Center

Methods (III)

Conduct of perfusion includes:

- systemic cooling to 25°C
- pH Stat strategy
- del Nido cardioplegia

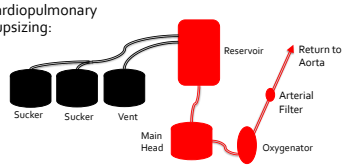
Stanford Children's Health

STANFORD SCHOOL OF MEDICINE

Results (I)

Modifications to the cardiopulmonary bypass circuit include upsizing:

- Oxygenator
- Reservoir
- Cannulae
- Vent catheter
- Tubing



Stanford Children's Health

STANFORD SCHOOL OF MEDICINE

Conduct of Perfusion

- Systemic High Flow
  - 200 cc/kg for initiation/cooling
  - 100cc/kg at 25 degrees
- High Hematocrit
  - 30-40 throughout CPB
  - 45-55 at termination
- Avoidance of Volatile Gas

Cardiac Index	Flow	Flow	cc/Kg
3.2:	1.057	1.584	240
3.0:	0.991	1.452	220
2.8:	0.925	1.320	200
2.6:	0.859	1.188	180
2.4:	0.793	1.056	160
2.2:	0.727	0.990	150
2.0:	0.661	0.924	140
1.8:	0.595	0.825	125
1.6:	0.529	0.660	100
1.0:	0.330	0.528	80
0.5:	0.165	0.330	50
Pt. Blood Volume		0.198	30
0 - 10 kg	= 85 cc	0.165	25
11- 20 kg	= 80 cc	0.132	20
21- 30 kg	= 75 cc	0.066	10
31- 40 kg	= 70 cc	0.033	5
41 + kg	= 65 cc		

Stanford Children's Health

STANFORD SCHOOL OF MEDICINE

Results (II)

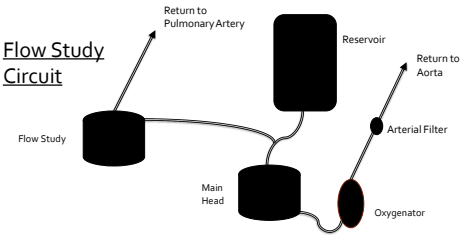
All circuits are modified to include the capability of performing an intraoperative flow study

This study is used to determine whether the VSD can be closed during surgery

Stanford Children's Health

STANFORD SCHOOL OF MEDICINE

Flow Study Circuit



Flow Study

The intraoperative flow study gradually ramps up to a flow of 3 liters/min/meters² to the pulmonary arteries

The pressure in the pulmonary artery is monitored, with an acceptable peak pressure of 25 mmHg

Those who fail the flow study would not have the VSD closed but instead would have a shunt placed

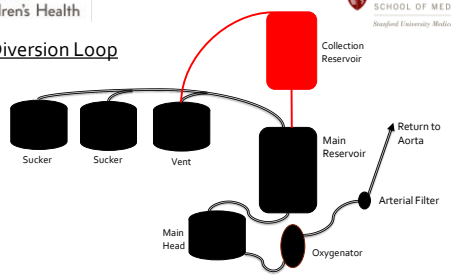
Results (III)

A collateral flow study circuit is set up for the first time operations in patients who are eligible for a single stage complete repair

These circuits are designed to measure the residual collateral flow after all of the MAPCAs have been harvested

Collection occurs during the time of cross clamp

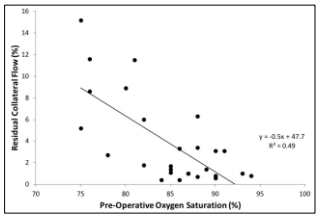
Diversion Loop



Stanford Children's Health

STANFORD SCHOOL OF MEDICINE

Residual Collateral Flow vs. Pre-op Saturation



Stanford Children's Health

STANFORD SCHOOL OF MEDICINE

Potential Implications of the Collateral Flow Study

Identify patients who have significant amount of residual collateral flow

This represents flow that is being diverted away from the systemic perfusion and may be important in patients undergoing 6-8 hours of cardiopulmonary bypass time

Identify unrecognized MAPCAs, as this would reveal itself by high amounts of collateral flow

Stanford Children's Health

STANFORD SCHOOL OF MEDICINE

Conclusions

Patients who require midline unifocalizations will invariably require very lengthy periods of support on cardiopulmonary bypass

We have adapted our perfusion circuitry to prepare for the demands on the bypass circuit to meet the requirements of this patient population

Our institution has developed a systematic approach for the conduct of perfusion to best serve our patients presenting with PA/VSD/ MAPCAs