Creation of the Fontan circulation in sheep
A survival model

J. Van Puyvelde[1], F. Rega[1], T. Minami[1], P. Claus[2], B. Cools[3], M. Gewillig[3], B. Meyns[1]

(1) Department of Cardiac Surgery - University Hospital Leuven
(2) Department of Cardiovascular Imaging and Dynamics- University Hospital Leuven
(3) Department of Paediatric Cardiology - University Hospital Leuven

BACKGROUND

Patients with a single-ventricle survive thanks to the Fontan palliation. Nevertheless, there is a growing number of Fontan patients with progressive heart failure. To validate therapeutic options in these patients we developed a chronic Fontan large animal model.

MATERIALS AND METHODS

A Fontan circulation was surgically created in 26 sheep (63.9 +/- 6.2 kg) without the use of cardiopulmonary bypass. The superior vena cava was anastomosed end-to-side to the pulmonary artery. The inferior vena cava was connected to the pulmonary artery by an ePTFE conduit and the inferior vena cava-right atrium junction was ligated (Fig. 1). Haemodynamics were recorded at the start of the surgery and after Fontan completion. Animals were followed for 21 weeks. A postoperative cardiac MRI was performed at 2 weeks in a small subgroup of animals (n=3).

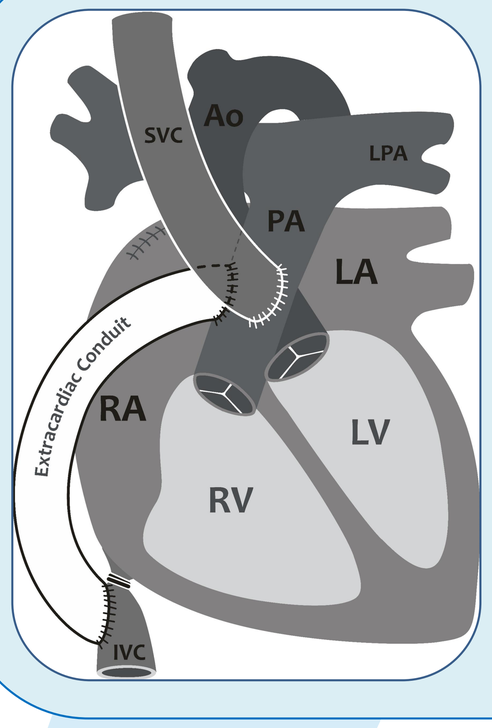


Figure 1: Schematic illustration of the experimental technique. SVC: Superior vena cava, IVC: Inferior vena cava, Ao: Aorta, PA: Main pulmonary artery, LPA: Left pulmonary artery, LA: Left atrium, RA: Right atrium, LV: Left ventricle, RV: Right ventricle.

	Baseline	TCPC	P value
Heart rate (bpm)	80 ± 14	86 ± 16	0.449
SpO2 (%)	99 ± 2	99 ± 3	0.602
Arterial blood pressure (mmHg)	66.4 ± 14.9	56.4 ± 13.5	**< 0.001**
Central venous pressure (mmHg)	4.7 ± 2.9	14.9 ± 2,5	**< 0.001**
Cardiac output (L/min)	5.05 ± 2	1.7 ± 1	**< 0.001**

Table 1: Pre- and postsurgical haemodynamic data

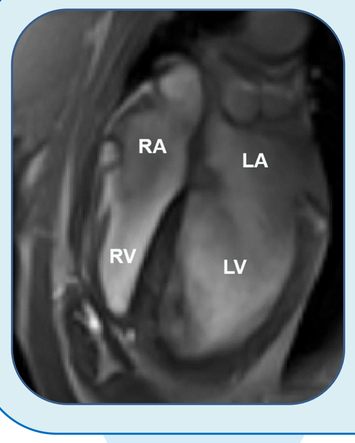
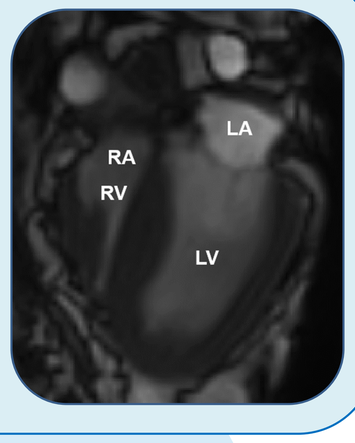


Figure 2: Long-axis MRI images of a normal control (left) and a chronic Fontan animal (right).



	Baseline (n=2)	TCPC (n=3)	P value
Left ventricle			
End-diastolic volume (ml), n (SD)	85 (35.4)	71 (30.3)	0.665
End-systolic volume (ml), n (SD)	50.5 (27.6)	32.7 (13.7)	0.389
Stroke volume (ml), n (SD)	34.5 (7.8)	38.7 (17.1)	0.776
Ventricular output (L/min), n (SD)	4.15 (1.05)	4.64 (2.06)	0.783
Right ventricle			
End-diastolic volume (ml), n (SD)	50 (17)	17.3 (5.5)	**< 0.05**
End-systolic volume (ml), n (SD)	17 (8.5)	14.3 (5)	0.679
Stroke volume (ml), n (SD)	33 (8.5)	3.3 (2.3)	**< 0.01**
Ventricular output (L/min), n (SD)	3.94 (1.16)	0.34 (0.24)	**< 0.05**

Table 2: Pre- and postsurgical MRI data

RESULTS

Total cavopulmonary connection was successfully performed in all 26 animals. Eleven animals (42%) died in the first 24 hours postoperatively. After creation of the Fontan circulation, central venous pressure increased significantly, mean arterial blood pressure and cardiac output decreased significantly (Table 1). Right ventricular output was significantly lower than total cardiac output in the subgroup of animals that underwent a cardiac MRI (Figure 2 & Table 2). Four animals completed the 21 weeks follow-up period.

CONCLUSION

This study shows that it is feasible to create a chronic animal model of the Fontan circulation. This animal model could facilitate studies on the pathophysiology of the failing Fontan circulation and play a role in the development of new therapeutic approaches, like cavopulmonary assist devices, to treat patients with a failing Fontan circulation.