

Original article

Fontan Operation. Hemodynamic Factors Associated With Postoperative Outcomes

Alberto Mendoza,^{a,*} Leticia Albert,^a Enrique Ruiz,^a Lorenzo Boni,^a Victoria Ramos,^b Jose M. Velasco,^a Dolores Herrera,^a Miguel A. Granados,^a Juan V. Comas,^a and Ana Perez^a

^aInstituto Pediátrico del Corazón, Hospital 12 de Octubre, Madrid, Spain

^bUnidad de Cuidados Intensivos Pediátricos, Hospital 12 de Octubre, Madrid, Spain

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ABSTRACT

Introduction and objectives: The Fontan operation is usually the final palliative procedure in patients with univentricular heart. The objectives of this study were, firstly, to describe the clinical and haemodynamic characteristics of a group of patients with univentricular physiology who had previously been palliated with a bidirectional Glenn procedure and, secondly, to identify risk factors that can influence postoperative outcomes after the Fontan operation.

Methods: Retrospective study with 32 patients who underwent a Fontan operation between March 2000 and December 2009. Clinical characteristics, catheterization data, type and duration of surgery were revised and analyzed as predictors of postoperative outcome.

Results: Hospital mortality was 3%. After a median follow-up of 44 months (interquartile range, 32-79), survival was 90%. Preoperative mean pulmonary arterial pressure (measured during catheterization) was correlated with late mortality. Of the remaining variables analyzed, the Nakata and McGoon indices, and duration of cardiopulmonary bypass showed the highest correlations with postoperative outcomes. Interventional catheterization before the Fontan operation was performed in 42% of patients.

Conclusions: Hospital mortality after the Fontan operation was very low. The performance of a haemodynamic study before the Fontan operation made it possible to select high-risk patients for surgery as well as permitting the performance of interventional procedures that could improve postoperative outcome in these patients.

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Operación de Fontan. Estudio de los factores hemodinámicos asociados a la evolución postoperatoria

RESUMEN

Introducción y objetivos: Los pacientes con corazón univentricular son sometidos a una serie de intervenciones paliativas que culminan en la operación de Fontan. El objetivo de este trabajo es revisar las características clínicas y hemodinámicas de un grupo de pacientes con fisiología univentricular paliados previamente con operación de Glenn bidireccional e identificar los factores de riesgo que influyen en la evolución postoperatoria de la cirugía de Fontan.

Métodos: Estudio retrospectivo de 32 pacientes sometidos a cirugía de Fontan entre marzo de 2000 y diciembre de 2009. Se revisaron las características clínicas, los datos derivados del cateterismo, el tipo de cirugía y los tiempos quirúrgicos y se buscó su relación con la evolución postoperatoria.

Resultados: La mortalidad hospitalaria fue del 3%. Tras una mediana [intervalo intercuartílico] de seguimiento de 44 meses [32-79], la supervivencia es del 90%. La presión media pulmonar medida en el cateterismo se relacionó con la mortalidad tardía. De las demás variables estudiadas, las que mejor se relacionaron con la evolución postoperatoria fueron los índices de Nakata y McGoon y el tiempo de circulación extracorpórea. En el 42% de los pacientes se realizó cateterismo intervencionista previo a la operación de Fontan.

Conclusiones: Realizamos la operación de Fontan con muy baja mortalidad hospitalaria. El cateterismo previo a la operación de Fontan permite seleccionar a los pacientes de alto riesgo para la cirugía así como realizar procedimientos intervencionistas que podrían mejorar la evolución postoperatoria.

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Palabras clave:

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Factores de riesgo

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* Corresponding author: Instituto Pediátrico del Corazón, Hospital 12 de Octubre, Avda. de Córdoba s/n, 28041 Madrid, Spain.

E-mail address: amendozas.hdoc@salud.madrid.org (A. Mendoza).

Abbreviations

CPB: cardiopulmonary bypass
 mPAP: mean pulmonary arterial pressure
 PICU: pediatric intensive care unit
 TPG: transpulmonary gradient

INTRODUCTION

Patients with a functionally univentricular heart undergo a series of interventions intended to passively direct systemic venous return toward pulmonary circulation, thereby leaving the single ventricle to boost systemic circulation. This is known as the Fontan situation or physiology.

For this delicate system to function correctly, good systolic and diastolic functioning is required, together with the presence of sinus rhythm, low pulmonary pressure and vascular resistance, and appropriate respiratory tree anatomy.¹ Ever since the Fontan technique was first introduced, cardiac catheterization has been considered a necessary part of pre-intervention evaluation.

There have been numerous modifications to the technique since it was first described by Fontan in 1971.² One such modification is the performance of an anastomosis between the superior vena cava and the pulmonary artery (bidirectional Glenn operation). This intermediate step is intended to stabilize pulmonary flow and avoid an overly heavy flow through the ventricle.³ Other modifications include the abandonment of the atriopulmonary connection in favor of a Fontan-type lateral tunnel,⁴ the use of extracardiac conduits,⁵ and the application of baffle fenestration.⁶

METHODS

Patients

Between March 2000 and December 2009, 32 patients with univentricular physiology who had previously received a bidirectional Glenn operation underwent Fontan surgery at our center. Background data collected included demographic information, type of heart disease, systemic ventricular anatomy, presence of heterotaxy, neonatal surgery type, age at which the bidirectional Glenn operation was performed, systemic atrioventricular valve regurgitation, and ventricular dysfunction by echocardiography (the last two conditions were dichotomized into “non-mild” and “moderate to severe”). Patient characteristics are shown in Table 1.

Cardiac Catheterization

All patients were catheterized in the 6 months prior to the Fontan procedure. None of the catheterized patients were excluded from the Fontan operation based on hemodynamic data. Catheterization was performed under general anesthesia using endotracheal intubation. Patients were disconnected from the respirator when pressures were measured. Pressures were measured and oximetry performed in the superior vena cava, the pulmonary arteries, the left atrium, the systemic ventricle, and the aorta. We used these data to calculate pulmonary flow and systemic and pulmonary vascular resistance based on published

formulas.⁷ Postoperative pressure in the Fontan was estimated using the following formula⁸:

$$\text{Estimated pressure in the Fontan} = \text{Left atrial pressure} + (\text{transpulmonary gradient [TPG]} / [\text{pulmonary/systemic flow ratio}])$$

All angiograms were reviewed and pulmonary artery diameters were measured and the results used to calculate the Nakata⁹ and McGoon indices as well as the lower lobe index. The findings of the Spicer et al. study¹⁰ were used to classify the degree of collateral circulation. Pulmonary branch distortion was deemed to be present when there was stenosis of >50% in branch caliber with respect to an adjacent segment or when there was marked hypoplasia of the branches.¹¹ Significant venovenous collaterals were deemed to be present when diameter was >2 mm.¹²

Surgical Procedures

We collected data on the surgical technique used (extracardiac or lateral tunnel Fontan, surgery with cardiopulmonary bypass [CPB], aortic clamping and / or circulatory arrest), surgical times, and associated procedures. Fontan fenestration was performed by direct anastomosis when the lateral tunnel approach was used and through a GORE-TEX[®] conduit in extracardiac cases.

Postoperative Variables and Follow-Up

Postoperative Fontan pressure was measured using a catheter inserted via the jugular vein into the superior vena cava. Left atrial

Table 1
Patient Characteristics

<i>Demographic data</i>	
Age at which Glenn performed, months	8.5 [5-13.3]
Age at which Fontan performed, years	5.3 [4.2-6.4]
Time between Glenn and Fontan, months	52.5 [41-65.5]
Sex (males/females)	15/17
Weight at Fontan, kg	17.250 [16-19]
Body surface, m ²	0.68 [0.64-0.74]
<i>Type of heart disease</i>	
Tricuspid atresia	10 (31)
HLHS	7 (22)
Single ventricle	7 (22)
Doble outlet right ventricle	4 (13)
Unbalanced AV canal	2 (6)
D-TGA, IVC and PS	1 (3)
Ebstein anomaly	1 (3)
<i>Heterotaxy</i>	4 (13)
<i>Type of ventricle</i>	
Right	12 (38)
Left	17 (53)
Two ventricles	3 (9)
<i>Neonatal surgery</i>	
Blalock-Taussig shunt	13 (41)
Norwood	8 (25)
Other surgery	3 (9)
No neonatal surgery	8 (25)
<i>Moderate to severe AV valve regurgitation</i>	5 (16)
<i>Moderate-severe ventricular dysfunction</i>	2 (6)

AV, atrioventricular; D-TGA, D-transposition of great arteries; HLHS, hypoplastic left heart syndrome; IVC, interventricular communication; PS, pulmonary stenosis. Data are expressed as no. (%) or medians [interquartile range].

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