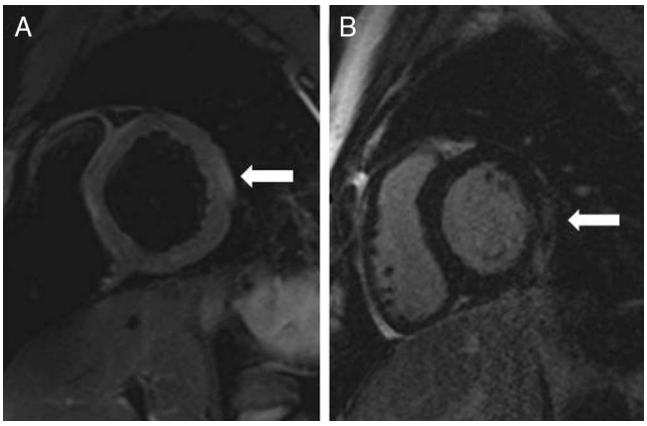

Figure 2. A: T2-weighted sequence showing an increase in intensity in the lateral wall of the left ventricle, corresponding to tissue edema. B: T1-weighted sequence showing delayed enhancement affecting the subepicardium and sparing the subendocardium.

creatine kinase-MB fraction was 79 μg/L. The remaining blood test results were normal. An echocardiogram showed normal anatomy of the coronary arteries, a moderately dilated left ventricle (end-diastolic diameter: 61 mm [Z-score=2.48]), an ejection fraction of 45% and moderate mitral failure. An MRI scan showed an ejection fraction of 50% with a normal end-diastolic volume. A delayed enhancement study showed a pattern of patchy subepicardial enhancement in the lateral wall. An area of increased signal intensity was visible in the T2-weighted MRI image, which was suggestive of edema (Fig. 2).

The patient's course was favorable; his systolic function returned to normal with a decrease in markers of damage. The suspected diagnosis was acute myocarditis. At admission, the results of polymerase chain reaction of blood and nasopharyngeal aspirate were negative for viruses; therefore the causal agent was not identified.

The third patient was a 10-year-old girl who presented to the emergency department after experiencing 4 episodes of oppressive chest pain, radiating to her arm. Each episode lasted approximately 1 h. An echocardiogram showed moderate ST-elevation of 1 mm in LII, LIII and aVF, with troponin T at 9.12 μg/L and creatine kinase-MB fraction at 272 μg/L. An echocardiogram showed normal coronary artery anatomy, a hypertrophic left ventricle (septum 10 mm [Z-score=2.77]; posterior wall 9 mm [Z-score=2.13]), which was not dilated, with an ejection fraction of 65%. T2-weighted MRI scan showed subepicardial areas of increased signal intensity in the free wall of the left ventricle. The delayed enhancement sequences showed generalized, subepicardial enhancement of the left ventricle, compatible with acute myocarditis. Polymerase chain reaction testing of blood and nasopharyngeal aspirate was negative for viruses. The patient's course was favorable.

Precordial pain is a presentation of acute myocarditis and, although uncommon in children, should be included in the differential diagnosis.

The usefulness of MRI in these patients has been previously reported.[6] The clinical course is usually favorable and the most commonly described causative agent is Parvovirus B19. In the cases reported here, the diagnostic utility of MRI should be emphasised as it allowed catheterization to be avoided in our patients. It should be performed as an emergency procedure and, if inconclusive, a coronary angiography should be conducted to rule out coronary disease.

Ferran Gran,[a,*] Amparo Castellote,[b] Laia Vega,[a] Dimpna Albert,[a] Queralt Ferrer,[a] and Joan Sanchez-De-Toledo[c]

[a]*Unidad de Cardiología Pediátrica, Hospital Universitario de la Vall d'Hebron, Universidad Autónoma de Barcelona, Barcelona, Spain*
[b]*Servicio de Radiología Pediátrica, Hospital Universitario de la Vall d'Hebron, Universidad Autónoma de Barcelona, Barcelona, Spain*
[c]*Unidad de Cuidados Intensivos Pediátricos, Hospital Universitario de la Vall d'Hebron, Universidad Autónoma de Barcelona, Barcelona, Spain*

*Corresponding author:
E-mail address: fgran@vhebron.net (F. Gran).

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Fenestration Closure After Fontan Surgery. Contributions of Percutaneous Interventionism

Cierre de fenestración tras la cirugía de Fontan. Aportaciones del intervencionismo percutáneo

To the Editor,

The Fontan procedure is the final step in surgery for patients with a single ventricle. The hemodynamic changes that occur after the procedure can have a negative impact on the immediate outcome due to a sudden increase in pulmonary artery pressure. Fenestration of the Fontan circuit during surgery is therefore a common procedure in high-risk patients,[1] although systemic saturation may decrease as a result. The development of percutaneous implantation devices has enabled fenestration closure without the need for further surgery when hemodynamic conditions allow.[2,3]

Here, we analyze our experience of percutaneous closure of fenestrations in the extracardiac circuit after the Fontan procedure, taking into account the properties of the new occlusion devices available. In addition, we study the changes in pulmonary artery

Table
Characteristics of the 13 Patients

Case	Underlying disease	Age, years	Weight, kg	Height, cm	Baseline saturation, %	Saturation after closure, %	Baseline PAP, mmHg	PAP after closure, mmHg	Baseline AoP, mmHg*	AoP after closure, mmHg*	Diameter of defect, mm	Device	Baseline FC	FC after closure
1	PAIS	8	17	123	87	99	11	12	96/45 (62)	97/47 (66)	5	VS 10 mm	II	I
2	PA+TA	15	50	160	93	96	14	15	97/60 (73)	95/59 (72)	3	PFO 18 mm	I	I
3	TA+D-TGA	8	23	125	88	95	18	18	92/62 (76)	86/53 (67)	3	PFO 18 mm	II	I
4	TA	12	38	145	91	97	14	14	102/58 (73)	88/57 (67)	4	PFO 18 mm	I	I
5	HLV	5	16	102	85	98	16	15	88/57 (67)	95/44 (59)	8	VS 12 mm	I	I
6	PAIS	10	32	136	92	98	22	22	101/52 (68)	99/52 (70)	5	PFO 18 mm	I	I
7	AT+PS	15	50	157	90	97	15	15	88/57 (67)	90/59 (71)	4.5	PFO 18 mm	II	II
8	TA	11	33	137	93	97	23	24	90/60 (70)	87/60 (70)	4	PFO 18 mm	I	I
9	AT+PS	11	43	140	89	95	15	15	96/52 (70)	96/51 (69)	3.7	PFO 18 mm	I	I
10	VS	17	53	157	90	98	21	23	108/73 (89)	102/70 (85)	3.3	Cribiform AS	III	III
11	DRVO+unrelated VS	9	21	115	87	94	16	15	99/54 (69)	100/54 (69)	3	Ductus occluder	I	I
12	TA+PS	9	24	122	80	92	21	21	99/61 (67)	90/56 (72)	4	PFO 18 mm	II	I
13	TA+VS+D-TGA	7	22	117	90	96	15	15	110/80 (95)	86/56 (67)	2	PFO 25 mm	I	I

AoP, aortic pressure; AS, atrial shunt; D-TGA, D-transposition of the great arteries; DRVO, double right ventricular outflow; FC, functional class; HLV, hypoplastic left ventricle; PA, pulmonary atresia; PAIS, pulmonary atresia with intact septum; PAP, mean pulmonary artery pressure; PFO, patent foramen ovale; PS, pulmonary stenosis; SV, single ventricle; TA, tricuspid atresia; VS, ventricular shunt.
* Systolic/diastolic (mean).

pressure, as well as oxygen saturation. Fourteen patients were included. Fenestration was indicated during the procedure because high-risk criteria were identified during catheterization performed prior to the Fontan procedure.[4,5] One patient was excluded from the analysis because no contrast flow was observed in the baseline angiography during the procedure.

Procedures were performed under general anesthetic. An artery was cannulated (4 Fr) for monitoring. Venous cannulation was performed (6, 7, or 8 Fr) for the therapeutic intervention, which was performed with monitoring by transesophageal echocardiography in 9 cases and intracardiac echocardiography in 5. After the procedure, the therapeutic regimen comprised low-molecular-weight heparin, acetylsalicylic acid for at least 6 months, and endocarditis prophylaxis with cefuroxime axetil for 1 week.

The quantitative data were expressed as means (standard deviation). We performed a Student *t* test for paired data to compare the mean pulmonary pressures and systemic saturation in the same patient.

The mean (standard deviation) duration of follow-up was 45 (41) months. No major complications were recorded during the procedures. Prior therapeutic catheterization had been performed in 8 of the 13 patients to close systemic-pulmonary collaterals. Of the 13 patients analyzed, 11 had systemic left ventricle and 2 systemic right ventricle (Table). None of the patients died during follow-up or were readmitted to hospital for cardiac causes.

In all cases, Amplatzer occluders were used. The device type was chosen in accordance with the postsurgical anatomy, which was assessed by computed tomography prior to the procedure. Multislice computed tomography was used to locate the site of fenestration and select the angiographic view that would best visualize the defect, sliced perpendicular to the largest diameter of the defect. Once catheterization had been performed, contrast was injected and the maximum diameter of fenestration was estimated, in accordance with the calibration marked with the catheter (Figure). Computed tomography and transesophageal or intracardiac echocardiography complemented these measures and contributed to better selection of the device size. In addition to the maximum diameter of the defect, the distance between the atrial chamber and the internal edge of the conduit was taken into account. The type of Amplatzer occluder was selected in accordance with the anatomical configuration. Devices for patent foramen ovale were used for narrower fenestration while those for ventricular shunts and patent ductus arteriosus were chosen for the wider ones (Table).

In 10 cases, the device for patent foramen ovale was used (18 mm in 9 patients and 25 mm in 1 patient). In 2 patients, a muscular ventricular shunt device was used, while in the remaining patient, a ductus closure device was chosen. Oxygen saturation increased significantly after closure of the fenestration (89% [3.6] vs 96% [2.0]; $P<.01$) without any evidence of a significant increase in pulmonary artery pressure (17 [3.6] mmHg vs 17.2 [3.9] mmHg).

Patients with congenital heart disease in the form of single ventricle circulation will need to undergo surgery several times during their lives. The development of devices placed by percutaneous procedures can help avoid surgical procedures in some of these patients. Closure of the fenestration is necessary due to the long-term harmful effects of chronic hypoxemia.

The experience in our hospital suggests that a multidisciplinary approach in these patients is essential when designing therapeutic strategies and establishing the timing of the interventions. The development of percutaneous implantation devices has allowed greater flexibility in surgery, which can be adapted to the

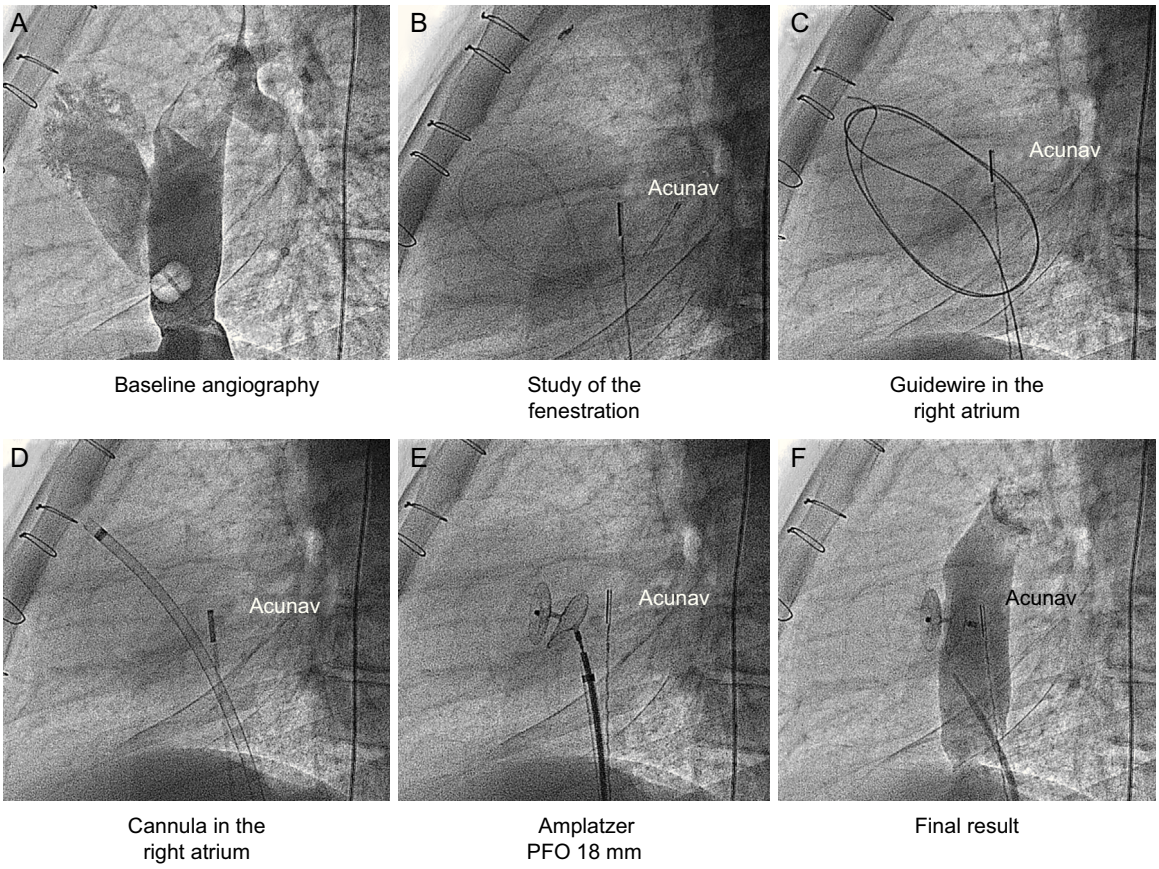

Figure. A, Baseline angiography. B, Study of the fenestration guided by intracardiac echocardiography. C, Guidewire in the right atrium. D, Cannula in the right atrium. E, Release of patent foramen ovale closure device. F, Final angiography. PFO, patent foramen ovale.

hemodynamic conditions of each patient. Closure of the Fontan fenestration by catheterization is a safe and effective technique in these patients.

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Marta Santisteban,[a,*] Manuel Pan,[a] Miguel Romero,[a] Jaime Casares,[b] Elena Gómez,[c] and José Suárez de Lezo[a]

[a]*Servicio de Cardiología, Hospital Universitario Reina Sofía, Córdoba, Spain*
[b]*Servicio de Cirugía Cardiovascular, Hospital Universitario Reina Sofía, Córdoba, Spain*
[c]*Servicio de Pediatría, Hospital Universitario Reina Sofía, Córdoba, Spain*

[*] Corresponding author.
E-mail address: marta_santisteban@hotmail.com (M. Santisteban).

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