CLINICAL RESEARCH

Retrograde catheterization of the right heart in patients with occluded femoral veins

Le cathétérisme rétrograde du cœur droit dans les patients avec l’occlusion des veines fémorales

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Summary

Background. — Occlusion of the femoral veins is a frequent complication of cardiac catheterization in small children. If the venous femoral approach is not available, a jugular approach is generally used for catheterization of the right heart.

Aims. — To describe and evaluate an alternative retrograde approach for catheterization of the right heart in small children with a ventricular septal defect or single ventricle.

Methods. — Between January 2004 and January 2007 we attempted retrograde catheterization of the right heart via the femoral artery using a 4 French sheath in eight children with occluded femoral veins. The procedure was planned under awake sedation.

Results. — Median age was five months (range 4–60) and median weight was 5 kg (range 4–10). Diagnoses were as follows: single ventricle (n = 6); pulmonary atresia and ventricular septal defect (n = 1); complex transposition of the great arteries (n = 1). The procedure was successful in six patients, enabling measurement of pulmonary arterial pressure and pulmonary angiography. The procedure was abandoned in two patients because of ventricular arrhythmias. One patient had concomitant dilatation of aortic recoarctation and one had embolization of aortopulmonary collaterals. With the exception of transient ventricular arrhythmias, no acute or late complications occurred. In particular, transient or permanent atrioventricular block,

Abbreviations: 4F, 4 French; AP, aorto-pulmonary; BT, blalock-Taussig; F, female; GA, general anaesthesia; M, Male; PA, pulmonary artery; PAP, pulmonary artery pressure; ND, not determined; PCPC, partial cavopulmonary connection; RV, right ventricle; TGA, transposition of the great arteries; VR, ventricular repair; VSD, ventricular septal defect.

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Cardiac catheterization can be performed using an antegrade or a retrograde approach. In general, antegrade catheterization is carried out via the femoral or jugular vein, while retrograde catheterization requires cannulation of the femoral artery. Catheterization of the right heart is usually performed using an antegrade approach. The retrograde approach is often used for radiofrequency ablation of accessory pathways [1,2] or to close a muscular ventricular septal defect (VSD) [3].

Bilateral thrombosis of the femoral veins is a frequent finding in small children with complex heart disease, who have had repeated cardiac catheterizations or a long stay in an intensive care unit [4—6]. In these patients, further cardiac catheterization of the right heart is usually performed using an antegrade approach. The retrograde approach is often used for radiofrequency ablation of accessory pathways [1,2] or to close a muscular ventricular septal defect (VSD) [3].

In our department, diagnostic cardiac catheterization is carried out under awake sedation. When bilateral occlusion of the femoral veins is discovered at the time of catheterization, the examination is rescheduled under general anaesthesia or a retrograde femoral arterial approach is attempted. In this study, we report on the retrograde catheterization of the right heart via the femoral artery in children with a VSD or single ventricle.

Conclusion. — Retrograde catheterization of the right heart in small children is feasible and relatively safe. This technique can be performed without general anaesthesia and avoids a jugular approach.

Résumé

Introduction. — L’occlusion des veines fémorales est une complication fréquente du cathétérisme cardiaque pédiatrique. L’abord jugulaire est généralement utilisé quand les veines fémorales sont occluses. Nous décrivons une possible technique alternative qui consiste dans le cathétérisme rétrograde du cœur droit à travers l’artère fémorale chez les petits enfants ayant une communication interventriculaire ou un ventricule unique.

Matériels et méthodes. — Pendant la période janvier 2004—janvier 2007, huit enfants avec occlusion bilatérale des veines fémorales ont eu une tentative de cathétérisme rétrograde du cœur droit à l’aide d’un sonde 4F. L’âge et le poids médian étaient de cinq mois (intervalle 4—60) et de 5 kg (intervalle 4—10). Les diagnostiques étaient : ventricule unique (n = 6) ; atrésie pulmonaire à septum ouvert (n = 1) ; et transposition complexe des gros vaisseaux (n = 1). L’examen, fait sous sédation, a été complété chez six enfants et a permis de mesurer la pression pulmonaire et de faire une angiographie pulmonaire. Chez deux enfants l’examen a été abandonné à cause d’arythmies ventriculaires. Deux enfants ont eu un geste interventionnel associé (une redilatation d’une recoarctation de l’aorte et une embolisation de collatérales aortopulmonaires). Hormis les arythmies ventriculaires transitoires nous n’avons pas observé de complications immédiates ou tardives, telles que le bloc atrioventriculaire, l’insuffisance aortique et la thrombose de l’artère fémorale canulée.

Conclusions. — Le cathétérisme rétrograde du cœur droit est faisable chez les petits enfants ayant une thrombose bilatérale des veines fémorales avec un faible risque. Cette technique peut être faite sous sédation et permet d’éviter l’abord jugulaire.
Table 1  Clinical and haemodynamic characteristics of patients at time of catheterization.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Diagnosis</th>
<th>Surgical treatment</th>
<th>Age (months)</th>
<th>Weight (kg)</th>
<th>Sex</th>
<th>Reason for catheterization</th>
<th>Concomitant interventions</th>
<th>Mean PAP (mmHg)</th>
<th>PT (min)</th>
<th>FT (min)</th>
<th>Outcome</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Pulmonary atresia; VSD</td>
<td>RV to PA conduit</td>
<td>11</td>
<td>6.4</td>
<td>M</td>
<td>Evaluation before complete repair</td>
<td>Embolization of AP collaterals</td>
<td>25</td>
<td>70</td>
<td>29</td>
<td>Complete repair</td>
</tr>
<tr>
<td>2</td>
<td>Single ventricle</td>
<td>Pulmonary banding</td>
<td>6</td>
<td>5</td>
<td>F</td>
<td>Evaluation before complete repair</td>
<td>None</td>
<td>17</td>
<td>45</td>
<td>10</td>
<td>PCPC</td>
</tr>
<tr>
<td>3</td>
<td>TGA; VSD</td>
<td>Pulmonary banding, BT shunt</td>
<td>60</td>
<td>10</td>
<td>M</td>
<td>Evaluation before complete repair</td>
<td>None</td>
<td>32</td>
<td>60</td>
<td>15</td>
<td>VR</td>
</tr>
<tr>
<td>4</td>
<td>Single ventricle</td>
<td>Norwood-Sano</td>
<td>4</td>
<td>4.2</td>
<td>M</td>
<td>Evaluation before PCPC</td>
<td>None</td>
<td>ND</td>
<td>40</td>
<td>10</td>
<td>Catheterization under GA; PCPC</td>
</tr>
<tr>
<td>5</td>
<td>Single ventricle</td>
<td>Norwood-Sano</td>
<td>5</td>
<td>4.4</td>
<td>F</td>
<td>Evaluation before PCPC</td>
<td>None</td>
<td>20</td>
<td>45</td>
<td>15</td>
<td>PCPC Abstention</td>
</tr>
<tr>
<td>6</td>
<td>Single ventricle</td>
<td>Norwood-Sano</td>
<td>7</td>
<td>5.7</td>
<td>F</td>
<td>Evaluation before PCPC</td>
<td>None</td>
<td>15</td>
<td>42</td>
<td>11</td>
<td>PCPC</td>
</tr>
<tr>
<td>7</td>
<td>Single ventricle</td>
<td>Norwood-Sano</td>
<td>4</td>
<td>4.4</td>
<td>M</td>
<td>Evaluation before PCPC</td>
<td>Dilatation of recoarctation</td>
<td>25</td>
<td>55</td>
<td>15</td>
<td>Late death</td>
</tr>
<tr>
<td>8</td>
<td>Single ventricle</td>
<td>Norwood-Sano</td>
<td>5</td>
<td>4.5</td>
<td>M</td>
<td>Evaluation before PCPC</td>
<td>None</td>
<td>ND</td>
<td>40</td>
<td>10</td>
<td>Catheterization under GA; PCPC</td>
</tr>
</tbody>
</table>

*a  Mild aortic incompetence.
Figure 1. Patient 4 (Table 1). Hypoplastic left heart, having undergone a Norwood-Sano repair. (A) The catheter is advanced through the ascending aorta into the systemic right ventricle; a soft guidewire is advanced into the right pulmonary artery. (B) The anteroposterior view shows symmetrical pulmonary perfusion; pulmonary arteries are mildly hypoplastic. (C) The lateral view shows a tight stenosis at the junction between the conduit and the pulmonary arteries.

Patient 4 (Table 1). Hypoplasie du cœur gauche ayant eu une réparation de Norwood-Sano. (A) Le cathéter atteint de l’artère ascendante le ventricule unique. Un guide hydrophile est avancé jusqu’à l’artère pulmonaire droite. (B) Chez le même patient l’angiographie pulmonaire montre une perfusion pulmonaire symétrique et des artères pulmonaires un peu hypoplasiques. (C) L’angiographie de profil montre une sténose serrée à la jonction distale du conduit ventricule unique-artère pulmonaire.

of the atrioventricular valve(s) and aorta was sought and described.

Results

The patients’ clinical and hemodynamic characteristics are shown in Table 1. At the time of catheterization, the median age was five months (range 4—60) and the median weight was 5 kg (range 4—10). The median duration of the procedure was 45 min (range 40—70) and of the fluoroscopy was 10 min (range 10—29). The procedure was abandoned in two patients with hypoplastic left heart and Norwood-Sano repair, because of repetitive ventricular arrhythmias, which occurred during attempts to enter the right ventricular outflow; for these patients, haemodynamic evaluation was carried out via the jugular vein under general anaesthesia. In six patients the pulmonary circulation was attained using the retrograde approach, enabling measurement of pulmonary arterial pressure and pulmonary angiography (Fig. 1). The superior vena cava was attained in one patient with complex transposition of the great arteries and pulmonary banding, making it possible to calculate the shunt, rule out positive streaming and exclude the persistence of left superior vena cava, suspected at echocardiography (Fig. 2).

Two patients had associated procedures: one patient with pulmonary atresia and a VSD, who had undergone a palliative repair, had embolization of aortopulmonary collateral vessels (Fig. 3), and one patient with a Norwood-Sano repair had dilatation of aortic recoarctation. These interventions were possible using the 4F sheath, if the intervention had necessitated a larger sheath or a longer procedural time we would have used the jugular approach under general anaesthesia. No acute complications occurred, with the exception of transient ventricular arrhythmias, in particular, no transient or permanent atrioventricular block was observed. Trivial aortic incompetence was present in two patients with Norwood-Sano repair, before and after catheterization (Table 1); the onset of new aortic incompetence was not observed. Acute thrombosis of the femoral artery did not occur; normal femoral pulses were present in all patients at follow-up.

At a median follow-up time of 15 months (range 10—36), four patients had partial cavopulmonary connection and two had biventricular repair. One patient (Patient 5; Table 1), who had elevated mean pulmonary arterial pressure and hypoplastic pulmonary arteries, has not been operated on. One late death occurred two months after cardiac catheterization due to persistent dysfunction of the systemic right ventricle; this patient (Patient 7; Table 1) had undergone dilatation of aortic recoarctation.

Figure 2. Patient 3 (Table 1). Complex transposition of the great artery, having undergone pulmonary banding. The catheter is advanced from the aorta into the right ventricle, then into the right atrium as far as the innominate vein, showing the absence of the left superior vena cava.

Patient 3 (Tableau 1). Transposition complexe des gros vaisseaux ayant eu un cerclage pulmonaire. Le cathéter a été avancé de l’aorte jusqu’au ventricule droit, l’oreillette droite et le tronc veineux innominé, montrant l’absence d’une veine cave supérieure gauche.
Catheterization of the right heart is usually achieved using a venous femoral approach. However, if femoral veins are occluded, the jugular approach has been recommended for interventional catheterization of the right heart \cite{9}, and for mitral valvuloplasty \cite{10}, and is generally performed under general anaesthesia. Cannulation of the jugular vein can be associated with acute and late complications, such as cardiac tamponade \cite{7}, puncture of the carotid artery \cite{4,5}, and Horner’s syndrome \cite{8}. We did not attempt a jugular approach, or a transhepatic approach (which can be performed successfully in the presence of occluded femoral veins in small children \cite{11}), because we prefer to use these techniques when general anaesthesia is available.

Electrophysiologists often use retrograde catheterization to ablate accessory pathways as an alternative to transseptal approach \cite{1,2}. However, several authors have reported that the frequency of occurrence of aortic lesions after retrograde ablation can be as high as 30% \cite{2,12}. The aortic valve may be injured directly by the catheter tip, when it is passed through the valve or by compression and stretching of the cusps by the catheter shaft during its prolonged placement in the left ventricle \cite{12,13}. Although the susceptibility of the valvar leaflets may be higher in young patients \cite{13}, it seems reasonable to suggest that the risk of valvar injuries from the retrograde aortic approach is in direct relation to the duration of the procedure. Our procedures were of reasonably short duration and the size of our catheter never exceeded 4F; we can assume, therefore, that when these precautions are taken, the risk of aortic valve damage is low.

Although a jugular approach under general anaesthesia is probably less invasive than retrograde catheterization, keeping the atrioventricular valve open is not well tolerated in patients with dysfunction of the systemic ventricle. This condition can be observed in patients with Norwood repair and aortic recoarctation.

Ventricular arrhythmia was the most important complication that we observed in our patients, probably due to the traumatic action of the guidewire while attempting to enter the pulmonary outflow.

In patients who have undergone Norwood-Sano repair, the geometry of the right ventricular outflow can make it difficult to advance the catheter into the pulmonary arteries, in fact, an acute angle can be present at the proximal or distal junction of the right ventricle to pulmonary arteries conduit \cite{14}. Ventricular tachycardia is poorly tolerated in children with single ventricle and, when it occurred, the procedure was abandoned.

Another potential complication of retrograde catheterization is acute or late thrombosis of the femoral arteries \cite{6}. Correct heparinization, strict surveillance after the procedure and aggressive treatment of acute occlusion should avoid thrombosis of the superficial femoral artery. Acute or late occlusion did not occur in our patients.

In conclusion, retrograde catheterization of the right heart can be considered to be a relatively safe option in children with occluded femoral veins and a ventricular septal defect or single ventricle, when the jugular approach with general anaesthesia is not available. Larger studies are required to confirm our preliminary results.

**Discussion**

We have shown that retrograde catheterization of the right heart is a feasible, low-risk procedure in small children. In particular, we did not observe the occurrence of new aortic regurgitation or atrioventricular block.

Catheterization of the right heart is usually achieved using a venous femoral approach. However, if femoral veins are occluded, the jugular approach has been recommended for interventional catheterization of the right heart \cite{9}, and for mitral valvuloplasty \cite{10}, and is generally performed under general anaesthesia. Cannulation of the jugular vein can be associated with acute and late complications, such as cardiac tamponade \cite{7}, puncture of the carotid artery \cite{4,5} and Horner’s syndrome \cite{8}. We did not attempt a jugular approach, or a transhepatic approach (which can be performed successfully in the presence of occluded femoral veins in small children \cite{11}), because we prefer to use these techniques when general anaesthesia is available.

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**Conflict of interest**

None declared.

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**References**


