How-to-do-it

A technique of fenestration for extracardiac Fontan with long-term patency

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Abstract

A technique for extracardiac conduit fenestration specifically devised to achieve long-term patency is presented. From 2001 to 2007, 65 patients underwent a fenestrated extracardiac Fontan procedure using this technique where the atrial orifice of the divided inferior vena cava was sutured in an end to side fashion to the leftward aspect of the conduit. The circumferential suture line was centred by the fenestration but remained away from the edge of the latter. All patients receive oral anticoagulation. Clinical and echocardiographic follow-up were obtained. Concurrent follow-up was 100%. There was one early death (mortality 1.5%). Two patients had Fontan failure requiring takedown and another two were transplanted. The fenestration was found to be patent in the rest of patients of the series (n = 60) at a median follow-up of 11 months (range 1—91). The mean velocity across the fenestration was 1.6 ± 0.55 m/s. No patient required reintervention related to the fenestration. All patients remained in sinus rhythm. This technique is easily reproducible, consistently provides long-term patency and low incidence of complications. The use of inferior vena cava orifice of the right atrium explains the absence of supra ventricular arrhythmias.

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1. Background

The Fontan procedure, initially described for tricuspid atresia [1], has become the palliative operation for all univentricular anatomy. Although fenestration in the inferior vena cava pathway was introduced to reduce the post-operative morbidity and mortality in high-risk patients [2,3], it has demonstrated to improve the clinical outcome of standard-risk patients [4,5] as well and recent studies suggest benefit in the long-term [6]. Initially described within the total cavopulmonary connection technique (TCPC) where the fenestration of the baffle is simple, the switch to the extracardiac conduit technique has seen a decline in the utilisation of the fenestration and a less reliable patency.

We describe a technique of fenestration specifically designed to maintain long-term patency with extracardiac conduit and demonstrate the efficacy in that respect with long-term echo studies.

2. Technique

Standard cardiopulmonary bypass technique with mild hypothermia and bicaval cannulation is used. The conduit is commonly either an 18 or a 20 mm stretch Gore-Tex® tube.

After completion of the upper anastomosis at the inferior margin of the confluence of the pulmonary arteries, the aorta is cross-clamped and myocardial protection is achieved by using antegrade warm blood cardioplegia. The total cavopulmonary connection is completed with the end-to-end anastomosis of the conduit to the IVC stump. The fenestration (always 4 mm) faces the atrial opening of IVC (Fig. 1a) in the lower left aspect part of the graft and is created by using a punch hole device.

The outer reinforcing layer from the graft surrounding the area of anastomosis is peeled off. Then the atrial orifice of the divided inferior vena cava (IVC) is sutured in an end to side fashion to the leftward aspect of the conduit. The circumferential suture line is centred by the fenestration but remains 5 mm away from the edge of the latter (Fig. 1b).

3. Results

Between 2001 and 2007, 65 patients underwent the technique described. Median age was 65 months (33—228).
Most of them (90.7%) had received a previous bidirectional cavopulmonary shunt (BCPS). Indications for Fontan completion were increased cyanosis and exertion limitation. Preoperative cardiac catheterisation was done in all patients. Concomitant procedures were performed in 24 (37%) patients. All patients were anticoagulated postoperatively with warfarin for INR 2—3.

Median duration of chest drainage and hospital stay was 7 days (4—31) and 11 days (5—81), respectively. There was one hospital death (mortality 1.5%). Two cases required Fontan takedown and two other were transplanted.

After a median follow-up time of 11 months (1—91), the echocardiographic studies showed that in the remaining 60 cases all fenestrations remained patent at the latest follow-up; with a mean velocity of 1.6 ± 0.55 m/s. Mean oxygen saturation during follow-up was 87.5 ± 5.7% at room air.

No patients have undergone reintervention related to the fenestration. Sinus rhythm was preserved in all patients.

4. Discussion

The haemodynamic benefits of a baffle fenestration involve augmentation of the ventricular preload increasing the cardiac output and lowering of the systemic venous pressure. In this setting, the increased output should outweigh, through increased systemic oxygen transport, the minor level of systemic desaturation caused by the right-to-left shunt at least at rest. It has shown to decrease pleural drainage, hospital length of stay and need for additional postoperative procedures [4].

The fenestration is associated also with long-term benefit in recent reports. Ono et al. [6] found that patients after fenestrated Fontan showed significantly lower arterial saturation but with higher cardiac index and less tachyarrhythmia compared to non-fenestrated.

Early techniques of fenestration were reported by using interposition of a PTFE conduit between the extracardiac conduit and the right atrial wall or a direct side-to-side anastomosis. This involves a side-biting clamp of the right atrial wall and a crowded anastomotic area with atrial muscle or use of a pericardial skirt [7]. Due to the low velocity flow this might be susceptible to thrombus formation. Spontaneous closure has been reported to occur between 26% and 40% during the first year.

The technique we describe has the following advantages:

- There are clean edges of fenestration orifice void of suture material and void of atrial pectinous muscle.
- The fluid dynamic is more effective.
- It is non-arrhythmogenic, as the anastomosis is to caval orifice, which is by definition electrically isolated.

At our institution, the priority is to maximise cardiac output for both short and long terms. CPB and aortic cross-clamping provide the surgeon with an optimal exposure, in order to perform the best fenestration possible. In our experience, the mean clamp time needed for the performance of the IVC anastomosis and fenestration was below 44 min (with 37% additional cardiac procedures).
The patency rate of the fenestration was 100%. We prefer not to occlude the fenestration unless there is significant cyanosis. We advocate that fenestrations are kept patent in all patients, as other groups do [8].

In conclusion, a fenestration can be achieved with 100% long-term patency in the extracardiac Fontan. This technique is easy to reproduce and exempt of major complications. It is not thrombogenic and generates no arrhythmias (Fig. 2).

References


Appendix A. Discussion conference

Dr S. Daebritz (Munich, Germany): First of all, the patients you analysed are a very mixed population with regard to age, underlying anatomy, and prior surgery, which makes it a little bit difficult to draw any conclusions. In addition, you did not fenestrate all of your patients. How did you select those patients which had fenestration?

Second, you had some patients which had early Fontan failure after the operation due to ventricular dysfunction. Was this dysfunction evident prior to the Fontan procedure? And if so, wouldn't it probably be better to list these patients early for transplantation rather than to make them high-risk transplant candidates by performing a Fontan? On the other hand, if ventricular dysfunction was not evident prior to surgery, was it probably due to the Fontan procedure, including the cross-clamping, which you performed in all of the patients?

In summary, the basic question remains: should we fenestrate the patients or not, creating a higher cardiac output for the price of desaturation and anticoagulation? Most of the time if we fenestrate patients, we do it for a smooth postoperative period to overcome the stress of surgery and cardiopulmonary bypass. This is, for example, shown by Frank Hanley who had a very low fenestration rate in patients where he performed Fontan without the use of an oxygenator. If we fenestrate for the better postoperative period, we are not always unhappy about the spontaneous closure of the fenestration in follow-up, which we see frequently and which you also observed. These spontaneous closures in good Fontan patients are usually not detected by clinical signs but just by echocardiography coincidentally.

To sum up, the major question is, whether or not it is justified to cross-clamp the aorta to create a non-occluding fenestration?

Dr Brizard: So I have noted all the questions. I'll try to respond to all of them.

It is now the policy of the unit to fenestrate all the Fontan. At the early stage in the unit, we had mixed feelings and the other consultants had the freedom to do what they wanted. One of the consultants was very opposed to the Fontan fenestration. But that's why we didn't do any statistics on this group because they're not comparable. There are less hypoplastic left hearts in the nonfenestrated group. But they do drain much longer. So I think it is justified to do a fenestration in all patients if you believe in the fenestration. I think if you do a preoperative evaluation and decide whether to fenestrate or not, in some instances you will be wrong. I prefer to fenestrate all patients and do the same form of fenestration for all patients.

The mixed, it's quite a heterogeneous group, they are all the univentricular patients in the series. Any unit has a series of mixed univentricular patients, that is the virtue of the Fontan circulation, it is a palliation for a wide group of cardiac anomalies.

The cross-clamp. I think that the cross-clamp in our area, where the cardioplegia is very sophisticated, is relatively safe. We have short cross-clamp. It's about 40 min. And there's lots of associated procedures in these patients. We use blood cardioplegia, it is repeated. We have increased the cross-clamp time in our unit in the last 10 years, because a significant part of the cross-clamp is due to myocardial protection. In the past, we used one dose of cardioplegia with very simple crystalloid cardioplegia. But, we could observe significant diastolic dysfunction in these patients. So we have longer cross-clamp, but we spent a lot of time protecting the myocardium.

Do you have all your answers?

Dr D. Barron (Birmingham, United Kingdom): First, we would agree with your philosophy, but we would perform a kissing technique using a side-biting clamp higher up laterally on the atrium and perform the fenestration without the need for a cross-clamp. Do you have a view on that?

Dr Brizard: Yes. I don't think it is the right way to do it. First, obviously, the stump is electrically isolated, and you don't create a scar in the right atrium if you use the IVC stump.

If you use a cross-clamp on the right atrium, you have a lot of muscle of the right atrium bulging into the clamp and your anastomosis is not very precise. You cannot do that anastomosis away from the edges of the punch hole, and therefore I don’t think you can guarantee the long-term patency or even the short-term patency of your fenestration.