

Original Article

“All is not lost”: management of intra-operative coronary injury during the arterial switch operation*

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Case presentation

A 2.5-kg newborn girl was prenatally diagnosed with transposition of the great arteries with ventricular and atrial septal defects. On the 5th day of life, she underwent the arterial switch operation with closure of atrial and ventricular septal defects. Coronary anatomy was consistent with the second most common pattern (1LAD;2R,Cx), but with very close juxtacommissural origin of both coronary arteries; this required take-down of the facing commissural post in order to harvest and fully mobilise both coronary buttons. Following cross-clamp removal, substantial bleeding from the aortic root was observed, as well as ischaemic discoloration of the myocardial territory tributary to the left anterior descending coronary artery. The heart was re-arrested, and partial transection of the left coronary artery was identified. Manipulation of the proximal coronary artery resulted unfortunately in complete transection of this diminutive vessel.

On exploring the options, we noted a very small left internal thoracic artery, which was marginally suitable as a conduit for left anterior descending coronary artery bypass. Considering the elapsed ischaemic time and the technical difficulty of re-anastomosing the left anterior descending coronary artery to the ascending aorta, we opted to temporise by at least resuscitating the heart. One end of a 1.25-mm coronary stent for off-pump coronary bypass (Fig 1a; Medtronic Inc., Minneapolis,

Minnesota, United States of America) was inserted into the transected proximal left anterior descending coronary artery. The other end was placed through the excised leftward pulmonary sinus and then anastomosed to a saphenous vein graft in turn connected to the proximal innominate artery (Fig 1b). Cardiac function improved immediately upon reperfusion and, over the ensuing hour, the micro-surgical team was mobilised. The heart was then re-arrested, and utilising the 8× magnification of a surgical microscope (OPMI Pentera[®], Carl Zeiss, Dublin, Ireland) the transected coronary artery was directly reimplanted onto the neo-aortic root with six interrupted 10-0 nylon ophthalmic sutures.

Given the length of ischaemic and cardiopulmonary bypass – 330 and 609 min, respectively – the dysfunctional heart was supported with extracorporeal membrane oxygenation. Delayed primary chest closure was carried out on post-operative day 3, and cervical extracorporeal membrane oxygenation decannulation was possible 3 days thereafter. The patient made a relatively unremarkable subsequent recovery and, at 16-month follow-up, is thriving, with no evidence of cardiac dysfunction or wall-motion abnormality.

Discussion

Coronary artery transfer is the most critical step of the arterial switch operation, and most acute, intra-operative problems arise from angulation or torsion rather than from laceration, transection, or electrocautery injury. Few reports have described coronary laceration or transection during the arterial switch operation and the management of this complication. Sharp injury to proximal coronary arteries has been associated with the intramural course of one or both proximal coronaries,^{1,2} and has been successfully

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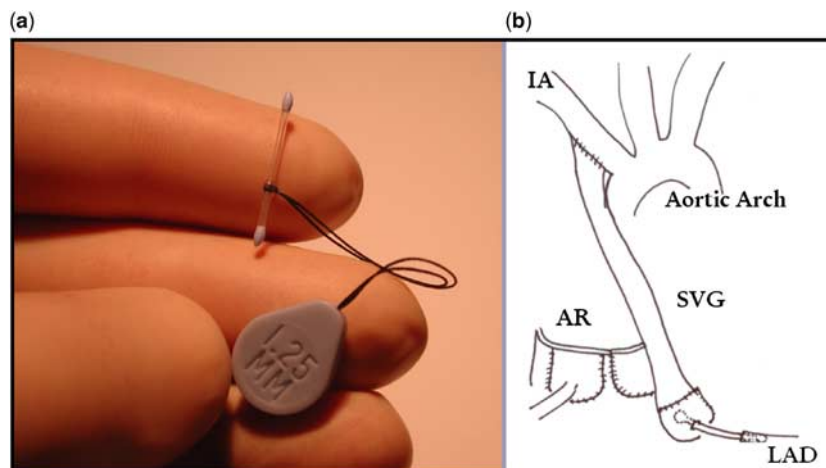


Figure 1.

Technique utilised for myocardial reperfusion. A 1.25-mm intra-coronary shunt designed for off-pump coronary artery bypass grafting (a) was inserted (b) into the open end of the proximal left anterior descending coronary artery (LAD) and into the stump of the previously mobilised coronary button. This was in turn anastomosed to a saphenous vein graft (SVG), interposed between LAD and innominate artery (IA). The shunt is not heparin coated.

managed by direct repair, reimplantation, patch arterioplasty,¹ interposition autologous arterial graft,³ or bypass to the left anterior descending coronary artery with pedicled left internal thoracic artery.⁴ However, the absolute number of fatalities and unsuccessful attempts at correcting this dramatic intra-operative problem is likely greater than the few reported successes.

In February, 2012, we attempted to address this issue by sending a questionnaire to experts with national and international reputation such as neonatal surgeons who had been performing the arterial switch operation for at least 10 years. A total of seven questions (Table 1) were posed, and 56 surgeons from 14 countries and four continents responded within 48 h of initial contact.

The individual experience in performing the arterial switch operation ranged between 11 and 30 years (median 20) for a total of ~1236 years. The number of arterial switch operation performed by the individual surgeon ranged between 45 and 1500, with the majority of surgeons having performed between 100 and 200 arterial switch operations during their career. Of 56 surgeons, 37 (66.1%) vividly recalled a total of 55 coronary lacerations or transections – ranging between 1 and 6 per surgeon. In all, 27 (49.1%) were associated with an intramural coronary artery.

“Simple” techniques – direct repair or patch repair – were utilised to address 37 (67.3%) injuries, whereas “complex” techniques – left internal thoracic artery graft in association with repair or patch repair – were utilised in 13 of the 55 cases (23.6%). In three patients, the artery was

Table 1. Questions regarding coronary injury during the arterial switch operation.

1. How long have you been performing the arterial switch operation?
2. In how many arterial switch operations have you been involved?
3. Have you ever experienced a coronary injury (laceration or transection, specifically)?
4. If so, was this in the setting of an intramural coronary artery?
5. What technique did you use to treat the injury?
6. Did the patient require ECMO or VAD support?
7. What was the ultimate outcome?

ECMO = extracorporeal membrane oxygenation; VAD = ventricular assist device

spatulated and reimplanted, in one an interposition graft with subclavian artery was utilised, and in one patient the arterial switch operation was aborted and direct coronary repair was followed by a Senning procedure. In no case was surgical repair, reimplantation, or bypass performed with the aid of a surgical microscope.

Of the 55 cases with coronary injury, there were a total of four (7.3%) operative deaths, with cumulative hospital mortality among patients with coronary injury of 40.0%, that is, 22 patients. Outcomes did not differ between cases in which “simple” or “complex” repairs were performed (mortality of 48.3% and 53.8%, respectively). Hospital mortality rose, however, from 12.9% to 70.0% when circulatory support was required at completion of the operation.

Although we acknowledge the limitations of a “memory-based” investigation, we believe that the results of this cursory survey can shed some light on

one of the worse complications that a neonatal cardiac surgeon can be faced with, and allow us to make some generic conclusions: (1) coronary artery injury occurs rarely and is associated with intramural course in nearly one-half of the cases and (2) is characterised by high operative mortality in case of need for circulatory support. (3) As many as two-thirds of neonatal cardiac surgeons are likely to encounter this complication during their career; (4) a variety of methods, including reaching out for – if available – colleagues well versed in micro-surgery, should be strongly considered, as long-term survival is possible even in the direst of circumstances.

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