



Original Article

Ductal closure with radiofrequency energy; outcomes of the first series



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ABSTRACT

Using radiofrequency energy for closure of the patent ductus arteriosus (PDA) has been reported by us previously. In this article we report the early and late outcome of the first group in whom patent ductus arteriosus has been occluded with radiofrequency. Six children with PDA were enrolled. The procedure was successful in five cases and transient hoarseness was observed in 2 cases as the only complication. © 2020 Cardiological Society of India. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Patent ductus arteriosus is a well-known congenital heart disease. Medium to large patent ductus arteriosus inflict a burden to the heart and should be closed. Closure of the small silent patent ductus arteriosus is controversial while some physicians apprehensive for the potential infection. Since many years ago various devices are available for ductal closure. Although device closure of the patent ductus arteriosus is highly successful with low complications, many parents are afraid of putting a foreign object in the body of their kids. On the other hand, device dislocation is still a considerable matter. Considering the above-mentioned aspects, we used the potential of radiofrequency energy for ductal closure. First, we used the energy for vascular closure in animal model¹ and then reported the first in-human case in which the ductus had been closed with radiofrequency.² Hereby, we are reporting our early experiences with the novel technique.

2. Methods

All procedures contributing to this work comply with local and international ethical standards including Helsinki declaration of 1975, as revised in 2008.

Six Children (2 male) with patent ductus arteriosus smaller than 3 mm were included. The age range was from 7 to 73 months, and the weight range was from 5.8 to 14 kg. All procedures were done under sedation and local anesthesia. We had open heart surgery room with all equipment including extracorporeal membrane oxygenation (ECMO) system nearby our catheterization room. A 5-Fr pigtail catheter was advanced to the aorta and a contrast injection was performed before the procedure in the lateral view. For the first case 6-Fr ablation catheter (Blazer II HTD, Boston, Massachusetts, United States of America) and for the others a 7-Fr ablation catheter (Stinger, Boston, Massachusetts, United States of America) were used. Based on our previous experiences and documentations in Pediatric electrophysiology laboratory and animal laboratory,¹ Radiofrequency energy (Maestro, Boston, Massachusetts, United States of America) with a power of 45 W and a temperature level of 65 °C was applied for 2 min. During radiofrequency application, multiple injections of small amounts of contrast media were done to rule out extravasation. After 2 min, the radiofrequency was stopped and contrast injection at the same volume and velocity as the first one was done for showing the final result.

Transthoracic echocardiography was done for all cases just after the procedure, the day after, and then at months 1, 3, 6, and 12 for all. Annual follow up visits and echocardiography was done thereafter up to 5 years post procedure.

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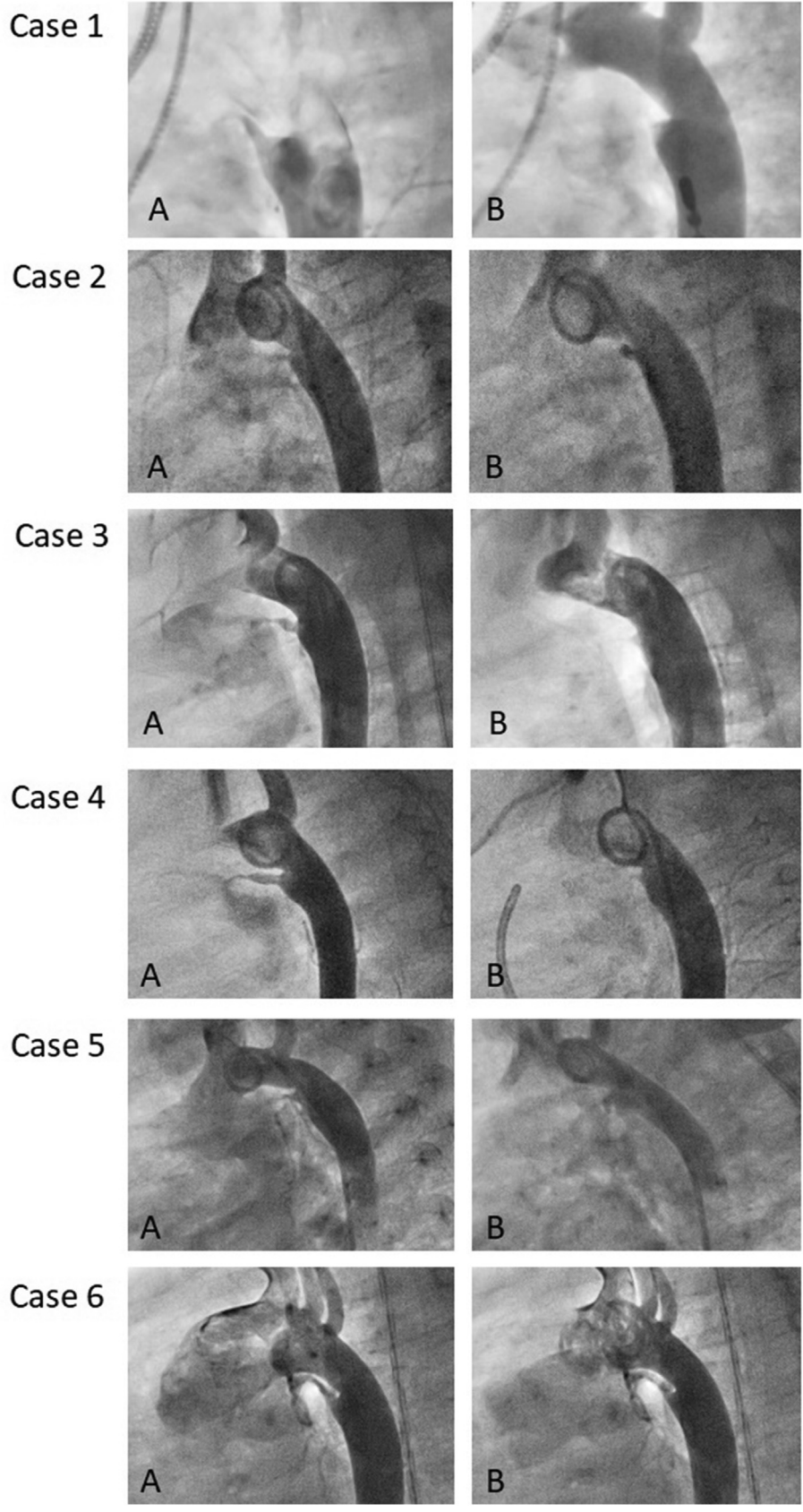


Fig. 1. angiograms of the cases in whom ductal occlusion with radiofrequency energy was tried. Panel A showed pre-procedural and panel B showed post-procedural angiogram.

Table 1
Demographics and the results of the cases in whom ductal occlusion with radiofrequency energy was tried.

Case number	Gender	Age	Weight (kg)	Outcome	Complication (s)
1	Male	34 months	10	Complete occlusion	None
2	Male	7 months	6.5	Complete occlusion	None
3	Female	6 years	14	Complete occlusion	Transient hoarseness
4	Female	16 months	9	Complete occlusion	None
5	Female	10 months	5.8	Complete occlusion	Transient hoarseness
6	Female	19 months	8.8	Unsuccessful occlusion	None

3. Results

Two minutes radiofrequency application was effective in five of six cases. For the only unsuccessful case, further burns were applied up to 6 min. Closure was not achieved. Demographics of the cases and the results are as shown in Table 1. Angiograms were also shown in Fig. 1. The only unsuccessful case was a 19-months-old girl with parachute mitral valve, severe mitral regurgitation, neglected complete heart block and moderate pulmonary hypertension. Whether the associated anomalies had a role in unsuccessful procedure or not is not clear. The ductus was occluded with coil, a temporary pacemaker was implanted and the patient subjected to permanent pacemaker implantation. The outcomes are summarized in Table 1.

Two patients experienced hoarseness of voice; the 6-year-old girl (weight = 14 kg) while speaking, and the 10-months-old girl (weight = 5.8 kg) while crying. Hoarseness decreased within few days and completely disappeared at 1-month follow-up in both cases.

4. Discussion

Except our previous reports,^{1,2} we did not find any report about using radiofrequency for vascular closure. However, radiofrequency energy has been used for varicose vein restriction for several years.³ The effect of radiofrequency in eliminating arrhythmia substrate is by its ability to produce cell death. The goal is achieved when the intracellular temperature rises beyond 50–55 °C.⁴ For vascular closure and eliminating blood flow within small vascular structures, however, we showed that inflammation and clot formation could have their roles in similar setting.¹ There is evidence to suggest that heat energy is responsible for vascular complications in different scenarios and formed the basis for our concept. The occurrence of pulmonary venous stenosis after pulmonary vein isolation in patients with atrial fibrillation confirmed that the heat injury is effective for vascular constriction without the need for clot for vascular flow restriction.⁵ Coronary artery stenosis after adjacent radiofrequency application is another supportive observation.⁶ Vascular narrowing as a complication of radiofrequency ablation has been published by some others.^{7–9}

Use of radiofrequency energy for closing patent ductus arteriosus could have some advantages including avoiding foreign body implantation, shortening the procedural and fluoroscopy times, precluding the risk of device dislocation, spares the patient from the undesirable sensation of hosting a foreign body, and reduction of the costs. The cost reduction, of course, is applicable for centers in which the reuse of non-lumen catheters has been approved.¹⁰ The value of this technique could be more prominent when closure of multiple inadvertent vessels (ex: aortopulmonary collateral vessels) is desired.

We observed transient hoarseness as the only complication. It is likely to be due to transient injury to the recurrent laryngeal nerve passing just beneath the patent ductus arteriosus. Further investigations are required to study the radiofrequency power to be

delivered or the duration of radiofrequency energy tolerated by the nerve, to avoid permanent injury. In a report of radiofrequency application in renal artery, one vascular dissection was reported amongst 153 cases¹¹; however, the direct role of radiofrequency energy for that complication has not been confirmed. Other possible complications are to be investigated.

The method, in current situation, could not however be a substitute for device closure of large patent ductus arteriosus and other large collateral vessels. The maximum vessel size in which the radiofrequency energy could be effective for closure is not clear. In our experience, the ductal size in the only unsuccessful case was not greatly larger than the others. Other factors such as the ductal structure could be implicated.

5. Conclusion

Radiofrequency energy could be used as a possible tool for closing small patent ductus arteriosus. The method could be extrapolated to various clinical scenarios like closure of collateral vessels, feeder vessels to tumors or bleeders etc.

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Declaration of competing interest

All authors have none to declare.

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