Sutureless Versus Conventional Pulmonary Vein Repair: A Magnetic Resonance Pilot Study

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Background. **Two different surgical techniques are used to repair anomalous pulmonary venous connection or pulmonary vein (PV) stenosis: the classic repair (CR) and the sutureless repair (SR). The purpose of this study was to compare the prevalence of PV stenosis between the two surgical approaches.**

Methods. **Patients were prospectively recruited irrespective of symptoms or previous imaging findings. Cardiac magnetic resonance imaging and echocardiography were performed in a blinded fashion on the same day.**

Results. **Twenty-five patients (13 male) after PV repair completed the study. Twelve patients had undergone CR and 13 SR (in 1 patient as a reoperation after CR). The median age at operation was 2 months (range: 1 day to 5 years) and was similar for both groups; the median age at the time of cardiac magnetic resonance was 9 years (range: 6 to 17 years) and 9 years (range: 6 to 14 years) for the CR and SR, respectively. Four patients had PV stenosis. All 4 patients had had total anomalous pulmonary venous connection, 1 patient had undergone repair with the CR and 2 with a primary SR; 1 patient had first undergone a CR, followed by a SR for stenosis. Echocardiography provided complete visualization of all PVs in only 11 patients (44%). Notable stenosis of at least one PV was missed by echocardiography in 2 patients.**

Conclusions. **This pilot study indicates that not only CR but also SR may be burdened by a risk of postoperative PV stenosis. Magnetic resonance imaging should be used routinely for the postoperative monitoring for the development of PV obstruction.**

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Surgical repair of pulmonary venous disorders, including anomalous connection and stenosis, is burdened by a substantial risk of postoperative (re-)stenosis. Pulmonary vein (PV) obstruction, occurring in an estimated 9% to 18% of cases [1, 2], is the primary determinant of long-term morbidity and death [3]. In principle, two different surgical techniques are used in PV repair: With the conventional repair (CR), the PVs are directly sutured to the left atrium (LA). In contrast, with the atriopericardial anastomosis, often referred to as sutureless repair (SR), a wide communication between the LA and the incised PVs is created with a pericardial pouch [4]. The hope is that, by avoiding direct sutures at the level of PV orifices, an important substrate for future stenosis can be abolished. Short-term [4] and mid-term [5, 6] results with the SR have been encouraging, although not universally so [7]. A systematic prospective comparison between the SR and the CR techniques with the use of cross-sectional imaging has not been undertaken. In clinical routine, postoperative surveillance for PV stenosis is performed most often by echocardiography. However, our group has previously demonstrated the limitation of echocardiography in the detection of PV obstruction [8, 9]. Cardiovascular magnetic resonance (CMR) imaging is the gold standard for the evaluation of PV patency [10]. The primary objective of the present study was to prospectively evaluate the prevalence of PV stenosis after surgical repair, using state-of-the-art imaging. The secondary objective was to study the diagnostic accuracy of echocardiography.

Patients and Methods

Patient Population

Eligible patients included children younger than 18 years without contraindications to a contrast-enhanced CMR scan who were able to undergo the investigation without

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The Video can be viewed in the online version of this article [https://doi.org/10.1016/j.athoracsur.2017.11.015] on http://www.annalsthoracicsurgery.org.

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Abbreviations and Acronyms

ASD	=	atrial septal defect
AVSD	=	atrioventricular septal defect
BV	=	biventricular
CMR	=	cardiovascular magnetic resonance
CoA	=	coarctation of aorta
CR	=	classic repair or conventional repair
CS	=	coronary sinus
DAO	=	descending aorta
DORV	=	double outlet right ventricle
F	=	female
HLHS	=	hypoplastic left heart syndrome
Inn v	=	innominate vein
IVC	=	inferior vena cava
L	=	left
LA	=	left atrium
LLPV	=	left lower pulmonary vein
LPV	=	left pulmonary vein
LSA	=	left subclavian artery
LUPV	=	left upper pulmonary vein
M	=	male
PAPVC	=	partial anomalous pulmonary venous connection
PDA	=	persistent arterial duct
PS	=	pulmonary stenosis
Pt	=	patient
PV	=	pulmonary vein
R	=	right
RAA	=	right aortic arch
RAI	=	right atrial isomerism
RLPV	=	right lower pulmonary vein
RMPV	=	right middle pulmonary vein
RPA	=	right pulmonary artery
RPV	=	right pulmonary vein
RSVC	=	right superior caval vein
RUPV	=	right upper pulmonary vein
SR	=	sutureless repair
SV	=	single ventricle
TA	=	tricuspid atresia
TAPVC	=	total anomalous pulmonary venous connection
VSD	=	ventricular septal defect

general anesthesia or conscious sedation (6 years and older). After approval by the institutional research ethics board patients who had undergone PV surgery between February 1994 and October 2011 were identified with the surgical database for this prospective cross-sectional cohort study. Patients with expected image degradation by an in situ vascular foreign body, such as stent or vascular clip, were excluded. After informed written consent CMR and echocardiography were performed on the same day, between 2012 and 2014. The CMR studies were conducted according to a standardized clinical protocol and analyzed by one of three experienced reviewers. Likewise, echocardiography was carried out by a single technologist and reported by one of two experienced readers. The CMR reader was blinded to the echocardiography results and vice versa.

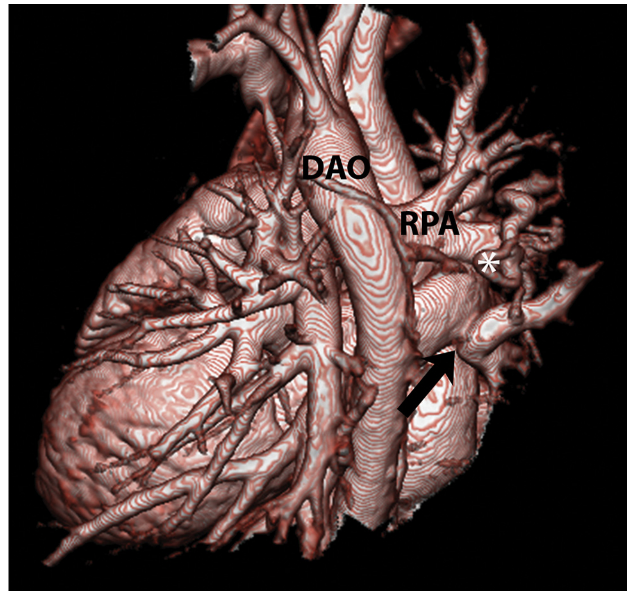

Fig 1. Right lower pulmonary vein stenosis. The three-dimensional volume-rendered reconstruction of a magnetic resonance angiogram in a 14-year-old girl after sutureless repair (patient no. 25), seen from levoposterior, showing discrete obstruction (arrow) at the ostium of the right lower pulmonary vein to the left atrium. Note the venovenous collateral (asterisk) arising from the stenotic vein upstream from the narrowing, connecting to the unobstructed right upper pulmonary vein (not shown). Phase-contrast imaging revealed redistribution of blood flow to the unobstructed right upper pulmonary vein and to the contralateral lung. For the volume-rendered reconstruction, see the rotational Video. (DAO = descending aorta; RPA = right pulmonary artery.)

Echocardiography

The echocardiographic studies were performed on either an IE33 (Phillips, Best, The Netherlands) or a GE Vivid7 machine (General Electrics Medical Systems, Milwaukee, WI) according to a standardized imaging protocol, including a spectral pulsed Doppler assessment of all PVs. A mean gradient of 3 mm Hg or more suggested PV stenosis.

CMR Imaging

MR scans were performed on a 1.5T Siemens scanner (Avanto; Siemens Medical Solutions, Erlangen, Germany) according to a uniform clinical protocol, including ventricular volumetry and phase-contrast flow velocity mapping of the branch pulmonary arteries and veins. Right and left ventricular end-diastolic and end-systolic volumes, indexed to body surface area and ejection fractions were derived from the short-axis cine stack [11]. Velocity patterns in the branch pulmonary arteries and veins were analyzed for signs of pulmonary hypertension and venous obstruction, respectively (see below). Contrast-enhanced MR angiography was performed after an injection of 0.1 mmol/kg gadobenate dimeglumine (MultiHance; Bracco Diagnostics, Monroe Township, NJ).

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