# Comparison of fusion imaging and two-dimensional angiography to guide percutaneous pulmonary vein interventions

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## INTRODUCTION

Primary and acquired pulmonary vein (PV) stenoses comprise a group of complex conditions often requiring numerous interventions in early childhood [1]. Despite advancements in surgical techniques, often repeated transcatheter interventions are common in this patient population [2]. Balloon dilation has demonstrated limited long-term efficacy, whereas stent implantation requires repeat dilations to match somatic growth or in-stent restenosis [3].

Modern angiographic imaging platforms allow three-dimensional (3D) guidance with a fusion of transesophageal echocardiography or pre-operative datasets like computed tomography (CT) and magnetic resonance imaging [4–6]. Early experiences showed promising reductions in contrast and radiation dose, fluoroscopy, and study times [7, 8].

We report our initial experience with fusion imaging (FI) to guide percutaneous PV interventions, and we compare FI and PV interventions that use traditional 2D angiography.

## METHODS

A retrospective review of the institutional database was performed to identify all patients who underwent percutaneous PV interventions. The study protocol was approved by the institutional review board (no. 19-2892) and patients' guardians provided written informed consent to participate in the study. Patient demographics including catheterization risk score for pediatrics (CRISP) and the risk for severe adverse events, pre-procedural cross-sectional imaging, and catheterization data were collected.

Computed tomography scans were performed as a routine diagnostic workup according to the standard institutional protocol for the visualization of PV. Therefore, radiation and contrast dose-related to CT imaging were not included in this analysis as patients would have been exposed to it regardless of whether scans were reutilized during cardiac catheterization.

The application of fusion software (VesselNavigator, Philips Healthcare, Eindhoven, The Netherlands) was described in detail elsewhere [9]. Briefly, it includes 4 steps: (1) segmentation of a previously obtained 3D dataset; (2) labeling key anatomy with marking rings/points, taking measurements, and saving optimal angulations; (3) registration of fluoroscopy with the labeled 3D reconstruction, and finally (4) guidance of the procedure with the 3D roadmap overlaid in the anterior-posterior plane (monoplane) and presented in one of several rendering modes.

Patients who underwent fusion of pre-catheter CT scans (available for the last 9 months of the studied period) for procedural guidance were matched (1:1) to those with standard 2D angiography. The following parameters were used for matching: the body surface area, a type of intervention (balloon dilation ± stent implantation), the number of treated veins. All matched patients had inter-atrial communication, hence there was

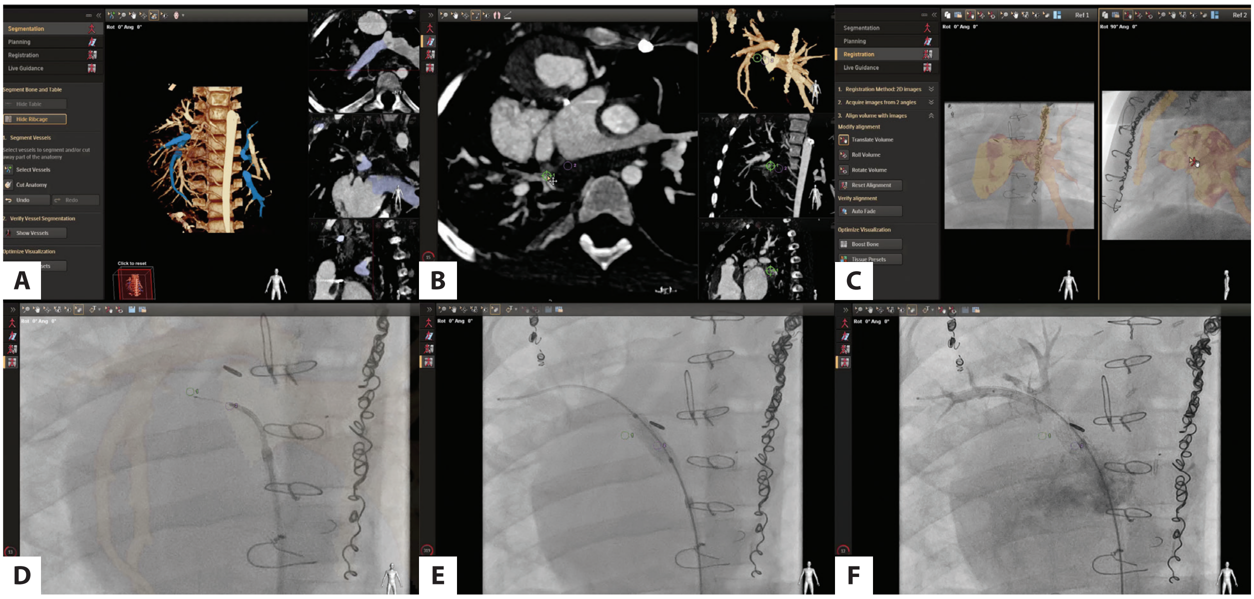


**Figure 1.** Fusion imaging for percutaneous pulmonary vein recanalization and stenting. VesselNavigator (Philips Healthcare, Eindhoven, The Netherlands) assisted the segmentation of contrast computed tomography scan (**A**). Pink and green marking points were placed to highlight the track between the left atrium and the right upper pulmonary vein (**B**). Previously placed coils were used for the registration of the 3D volume with stored fluoroscopy in two perpendicular projections (**C**). Three-dimensional reconstruction with marking points was used to guide pulmonary vein perforation and subsequent stent implantation (**D–F**)

no need for trans-septal puncture. The procedural time was calculated from the moment of vessel cannulation to sheath removal. Registration of fluoroscopy and 3D roadmap was performed after obtaining vessel access, during the setting up of the isocenter.

### *Statistical analysis*

Analyses were performed using JMP Pro 13.0 (SAS Institute, Cary, NC, US). Data are reported as number and percentage for qualitative values and median (interquartile range) for quantitative values. All comparisons were performed using the Wilcoxon-matched pairs signed-rank test. The *P*-value $<0.05$ was considered significant.

## RESULTS AND DISCUSSION

Over a period of 18 months, 24 patients with PV stenosis underwent 64 catheterizations: 8 diagnostic and 56 interventional. Fusion imaging was utilized during 7 interventional catheterizations (Figure 1). One case of radiofrequency PV perforation with FI was excluded from further analysis due to the lack of a matching example in the 2D group. There were no significant differences between those with 2D guidance (n = 6) and FI (n = 6) in terms of body surface area (median 0.38 vs. 0.4 $m^2$; $P = 0.81$), weight (7.5 vs. 7.8 kg; $P = 0.99$), or age (13.5 vs. 19 months; $P = 0.625$) (Supplementary material, *Table S1*). There were no differences in the CRISP score (11 vs. 10 points; $P = 0.56$) or the risk for severe adverse events (14.4 vs. 14.4 %; $P = 0.99$). All patients in each group underwent balloon dilation, with 3 patients in each group having additional stent implantation. Using FI resulted in lower contrast utilization (3.7 vs. 2.4 ml/kg, decrease of 31.5%; $P = 0.22$) and radiation exposure (Air kerma: 288 vs. 53 mGy, decrease of 82%; $P = 0.22$; Dose area product: 8852 vs. 1020 mGy × $cm^2$, decrease of 88.5%; $P = 0.31$). Fluoroscopy (71 vs. 52 min, decrease of 27%; $P = 0.44$) and total study times (256 vs. 165 min, decrease of 35.5%; $P = 0.22$) were also shorter in the cases guided with FI. However, the obtained differences were not statistically significant.

Percutaneous treatment of PV remains a challenging task requiring repeated anesthesia, contrast, and radiation exposure in the most vulnerable early stages of life [2, 3]. In addition to evolving transcatheter techniques and the availability of improved equipment, efforts have been made to improve non-invasive imaging for diagnosis and follow-up of PV stenosis [1]. Computed tomography provides precise information for diagnosis and procedural planning of PV interventions; however, it comes at a cost of exposing patients to radiation and contrast. Re-utilization of CT 3D data sets might allow reduction of the number of diagnostic 2D angiographies and, consequently, lower radiation and contrast usage during cardiac catheterization.

Until recently 2D imaging was the gold standard for the guidance of PV interventions. We have applied our experience in 3D guidance for cardiac catheterization in various congenital heart defects to PV interventions to reduce the catheterization burden to the patients [8–10]. Our initial, limited experience shows a possibility for lower contrast utilization and radiation exposure and shorter fluoroscopy and study times with the FI guidance compared to 2D angiography. Larger patient groups may allow us to determine if these differences are statistically significant.

## *Supplementary material*

Supplementary material is available at https://journals.viamedica.pl/kardiologia_polska.

## *Article information*

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