Statistical Shape Analysis of the Right Ventricular Outflow Tract in Patients with Tetralogy of Fallot

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Abstract (300 word limit)

Tetralogy of Fallot (TOF) is the most common congenital heart disease [1] with >80% of children expected to live beyond the age of 40 [2]. However, due to gradual loss of pulmonary valve function after initial surgical repair, resulting in severe pulmonary regurgitation (PR) [3], TOF patients require frequent surgical revisions. To delay open-heart surgery, a non-invasive percutaneous pulmonary valve implantation (PPVI) device was first introduced by Bonhoeffer et al. [4] showing satisfactory clinical performance [5]. Morphology still limits PPVI eligibility however. We focus on automatically defining the shape of the right ventricular outflow tract (RVOT) in TOF patients with PR late after surgical repair to assess the variations of anatomy and guide the design of new PPVI devices.

TOF patients (n=59, age 25±15 years) referred to our centre for follow-up cardiovascular magnetic resonance imaging (MRI) between August 2007 and April 2017 were retrospectively selected for this study – inclusion criteria: i) steady-state free precession cardiac-gated 3D whole-heart images; ii) moderate to severe PR (regurgitant fraction (RF) 39±10%); and iii) no metal artefacts. A statistical shape analysis (SSA) framework [8] was used to calculate the principal component (PC) modes of shape variation in the population from unsupervised statistical learning. The first three PC modes accounted for 36% of the variance. Mode 1 was most correlated to BSA ($r=0.66$, $p\leq0.001$) describing size differences, together with mode 2 ($r=0.47$, $p\leq0.001$). Mode 2 revealed presence of a highly enlarged pulmonary trunk whilst mode 3 described elongation of the vessel and correlated with vessel centreline length ($r=0.57$, $p\leq 0.001$). Mode 3 was inversely correlated with pulmonary RF ($r=-0.43$, $p\leq 0.001$). Advanced image processing and statistical shape analysis of the RVOT in TOF identifies features important to guide the design and optimisation of new PPVI devices, benefitting the largest number of patients requiring a new valve.

Image

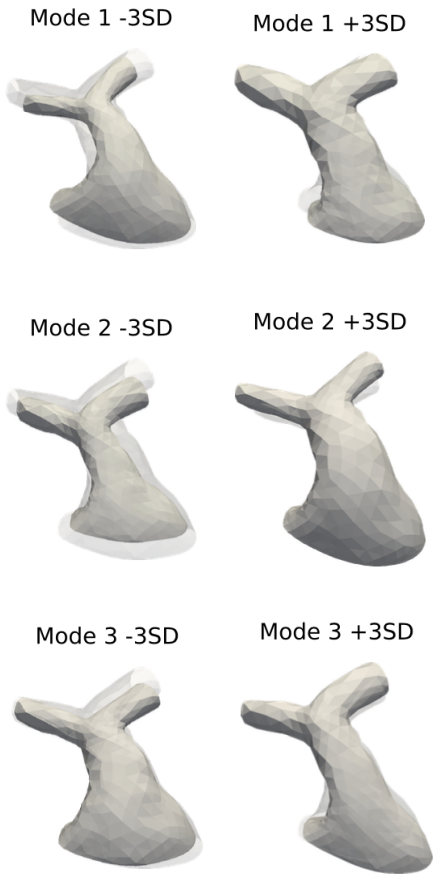


Figure 1 - Representation of the principal modes of shape variation in the population

Recent Publications (minimum 5)

1. Hunter, PLoS ONE (2013)
2. Moons, Circulation (2010)
3. Frigiola, Circulation (2004)
4. Bonhoeffer, Lancet (2000)
5. Ansari, JACC (2015)
6. Zuluaga, LNCS (2013)
7. Antiga, MBEC (2008)
8. Bruse, BMC MI (2016)



Biography (150 word limit)

Stephane Couvreur is a research assistant working on applications of data science in paediatric cardiology. His research focuses on congenital heart diseases, which are cardiac malformations present in less than 1% of live births. The methodology used in his research invesitgates patterns in cardiac magnetic resonance imagery.

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Notes/Comments: