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Stereo-Lithographic Models in children with congenital heart disease: an Up-to-Date.

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Background: Congenital heart diseases (CHD) represent a very attractive field of application for three-dimensional (3D) printed models. The purpose of this study is to provide a critical up- to-date of current researchers on stereo-lithographic models in children with CHD.
Methods: A systematic search in the National Library of Medicine was conducted in December 2015 starting from the key words: 3d/Stereo-Lithographic models, cardiac, congenital heart disease. The search was further refined by adding the key words children, magnetic resonance imaging (MRI), computed tomography (CT) and 3D-echocardiography. **Results:** 17 works were selected for the final analysis, reporting 3d-models reconstruction in 97 cases of CHD. Our research revealed how consistent steps have made in the last decades. Stereo-lithographic representations are able to reproduce complex cardiac/extra-cardiac anatomy including small details with very limited range of errors (<1 mm). However a series of limitations remain yet. Several steps in the building of 3D models remain highly operator dependent (i.e. images acquisition and their selection, the segmentation process, the choice of materials for printing). In fact not surprisingly in a very innovative field there is a lack of standardization in: 1) procedures employed to collect images (i.e. different techniques-MRI/CT-often used interchangeably, differences in the sequences/projections used, 3D-echo rarely used), 2) in segmentation process (i.e. different software used for DICOM conversion into printable formats, use of manual vs semi-automated/automated segmentation, whether to use systole or diastole not defined); 3) in printers and materials employed for printing. Current 3-D models may be rigid or rubber like flexible (that may be used for surgical simulation) but remain unable to reproduce physiological variations occurring during the cardiac cycle. Furthermore the high costs, particularly those related to software able to convert DICOM files into printable formats and cost of print itself, greatly limit a more extensive use of 3D models. **Conclusions:** stereo-lithographic representation of complex CHD anatomy are feasible and very accurate thus may be helpful to plan surgical/percutaneous management in selected cases. Extensive studies to test feasibility, diagnostic accuracy, and cost-effectiveness of stereo-lithographic models in pediatric cardiac surgery/interventional cardiology are warranted. **Table-1:** 3D-print in CHD: Some of the major works.

Author		***Sample size and Age***	***CHD***	***Software for segmentation***	***Printer***	***Materials***
Ngan 2 006, Canada	CT	6 cases (6 mths -2 yrs)	PA+VSD+MA PCAs	Mimics, Materialize, Lueven, Belgium	Stratasys Prodigy Plus (Stratasy Inc, Minn)	Solid acrylic or plastic model
Noecker *2006 USA*	CT	11 cases (age, 3 years; 2 days -13 yrs)	With and without CHD	Stereolithography machine (SLA 250/30A, 3D Sys, Valencia, USA)	Z printer 310, Z Corporation, Burlington MA,USA	polyurethane + silicone rubber
Schmauss Germany 2014	CT /MRI	4 cases (3 month-16 yrs)	1 vascular ring; 1 VSD, 2 failing SV	Amira (Mercury Comp.Systems, MA, USA)	Spectrum Z™ 510, Z Corporation, Burlington, MA, USA	starch/cellulose+elastomeric urethane resin
Schievano 2007 London	MR	12 cases (20 yrs; 9–39 yrs)	Pts requiring PV implant	Not reported	P1500, Stratasys, (Stratasy Inc, Minn)	Thermoplastic resin
Shiraishi 2010 Japan	CT	8 cases (4 days-4 years)	Aco, HLHS, DORV, AVSD, APVER. PDA	Stereolithography biomodelling company (Japan)	Not reported	Rubber like models urethane
Olivieri 2015 USA	3D echo	9 cases	8 VSD, 1 peri-valvular leak	Mimics, Materialize, Lueven, Belgium	Obiect 500, Connex, Polyjet	Not reported