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Advanced Postprocessing of Cardiac CTA

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Functional Evaluation of Cardiac CTA

Commercially available workstations have software packages to provide volumetric analysis for cardiac CTA. In children, it is best to obtain the data prospectively to reduce radiation exposure. The rapid heart rate of infants results in data and phases of a larger portion of the cardiac cycle than in adults with the same amount of padding. End-systolic and end-diastolic volumes are obtained easily for both right and left ventricles. The typical part of the phase to obtain the end-diastolic data is at 85–90 % of the cardiac cycle. The typical part of the phase to obtain the end-systolic data is at 45–55 % of the cardiac cycle. Once volumes have been determined for end systole and end diastole, the ejection fraction and stroke volume can be calculated and provided as part of the report. It is helpful to divide the end-diastolic and end-systolic volumes by body surface area to provide indexed volumes. Indexed volumes are obtained by dividing the gross end-diastolic and end-systolic volume of the right and left ventricles by the body surface area (Figs. 3.1, 3.2 and Table 3.1).

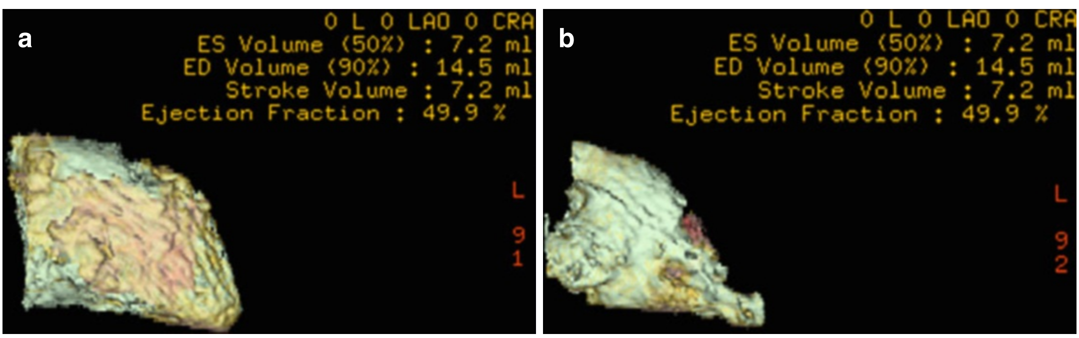

Fig. 3.1 End-systolic (**a**) and end-diastolic (**b**) volume of the right ventricle. Evaluation of the data is provided in Table 3.1

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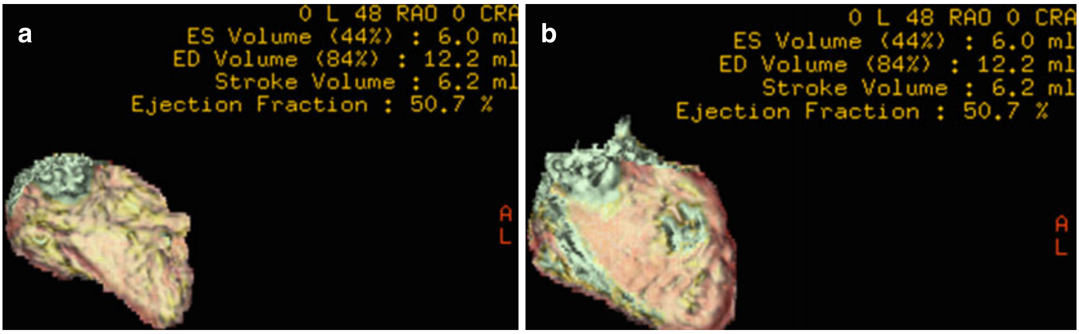

Fig. 3.2 End-systolic (**a**) and end-diastolic (**b**) volume of the left ventricle. Evaluation of the data is provided in Table 3.1

Table 3.1 Functional cardiac CTA calculations

RV and LV parameters	Gross volume, *mL*	BSA, *m*^{2}	Gross volume ÷ BSA = volume index, *mL/m*^{2}	Normal volume index range, *mL/m*^{2}[a]	Ejection fraction, % (*range*, %)
RV end-systolic	7.2	0.2	36	19–30	–
RV end-diastolic	14.5	0.2	72.5	62–88	–
RV stroke volume	7.2	–	–	No normal indexed values	–
RV	–	–	–	–	49.9 (40–60)
LV end-systolic	6.0	0.2	30	17–37	–
LV end-diastolic	12.2	0.2	61	50–84	–
LV stroke volume	6.2	0.2	31	30–65	–
LV	–	–	–	–	50.7 (50–70)

BSA body surface area, *LV* left ventricular, *RV* right ventricular

[a]Normal values are taken from GE report card postprocessing software

Volumetric Analysis of Blood Flow

CT postprocessing of pulmonary vasculature may be performed using a commercially available three-dimensional (3D) workstation. The pulmonary vasculature (pulmonary arteries and veins) is grown out with the aid of an automated vessel selection tool. The arterial pulmonary circulation is grown out proximally from the pulmonary valve and distally as far as the smallest opacified vessel. The venous pulmonary circulation is grown out similarly from the left atrial ostia to the smallest opacified vessel. The automated selection is then reviewed for any nonvascular components, which are cut out from the selection manually. Once the pulmonary vasculature has been grown out fully, the left and right pulmonary circulations are divided by hand. The division point for each side occurs at the origin of the right main and left main pulmonary artery. The main pulmonary artery is then excluded. Once the selections are complete, the pulmonary vascular volume is calculated using the workstation volume quantification software. This process may be better appreciated in Fig. 3.3.

Fig. 3.3 Right and left pulmonary arteries and veins grown out for volumetric analysis of blood flow. The percent flow to the right is 81.006 (total right volume) divided by 135.992 (total combined volume), which equals 60 % volumetric flow to the right lung. Using the same calculation for the left (54.986/135.992), there is 40 % volumetric flow to the left lung

Statistical Analysis

The right pulmonary blood volume percentage is obtained by dividing the pulmonary blood volume from the right side by the total pulmonary blood volume from both the right and left sides. The same calculation is performed to determine the percentage of pulmonary blood volume on the left.

Standardized Color Coding

Most of the 3D images in this book are color coded. A standardized 3D color-coding scheme is used to help communicate findings. This technique has been used to improve the understanding of complex anatomy. Using the images in conferences and consultations allows viewers to quickly and efficiently understand the anatomy. This has been particularly useful for surgeons, cardiologists, residents, nurses, students, and other health care providers. Three-dimensional images are particularly useful when demonstrating the anatomy in patients with complex congenital heart disease. This color scheme is derived from a palette of commonly used colors currently associated with the arterial and venous structures, such as red for the aorta, blue for the pulmonary veins, and so forth.

Currently, we use a commercially available workstation to segment the anatomic components. This process typically takes 20 min to perform. Once the anatomic structures are segmented, colors are assigned to the segmented anatomy using the color coding scheme shown in Figs. 3.4, 3.5, 3.6, 3.7, and 3.8.

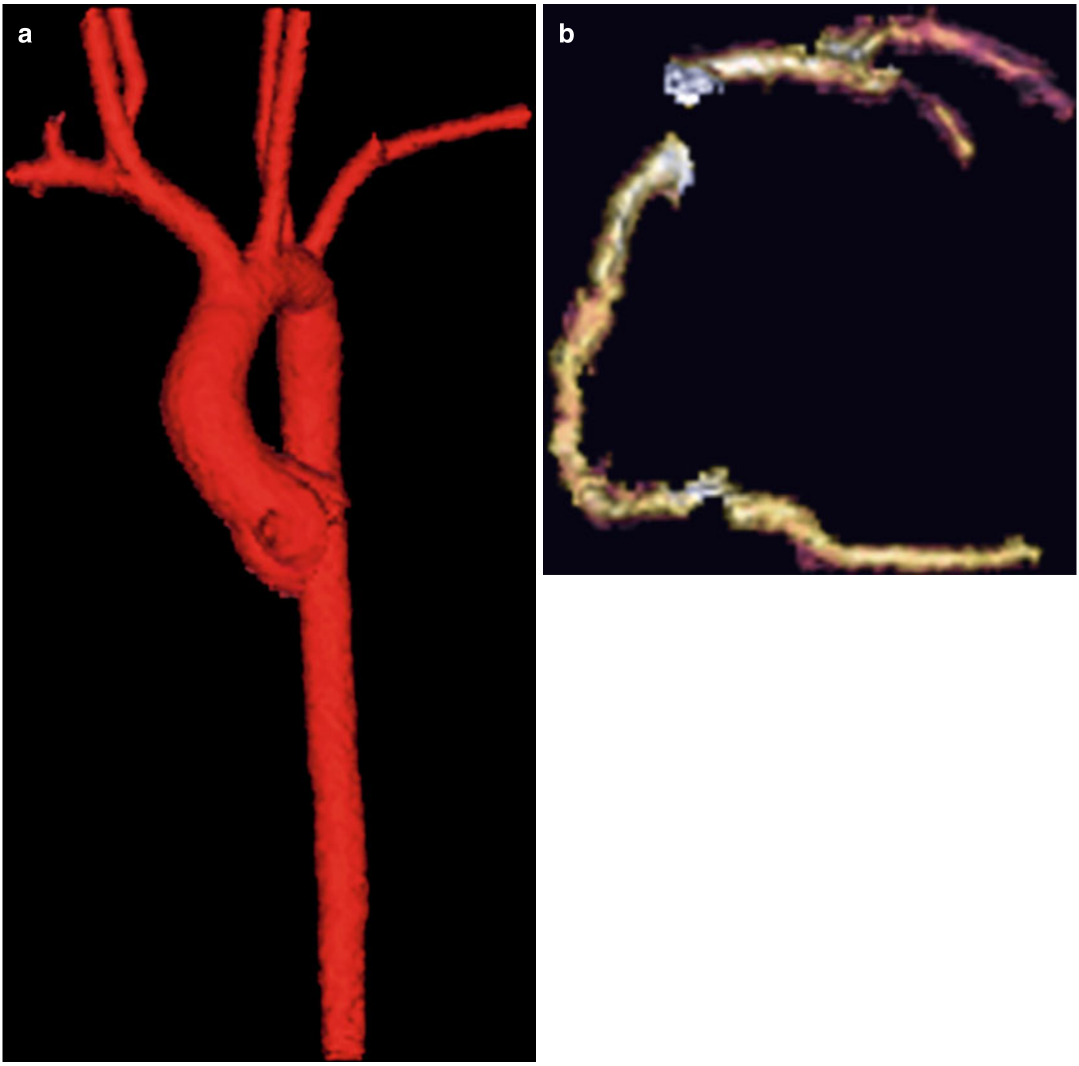

Fig. 3.4 (**a**) *Red* is used for the aorta. (**b**) The coronary arteries are a neutral color

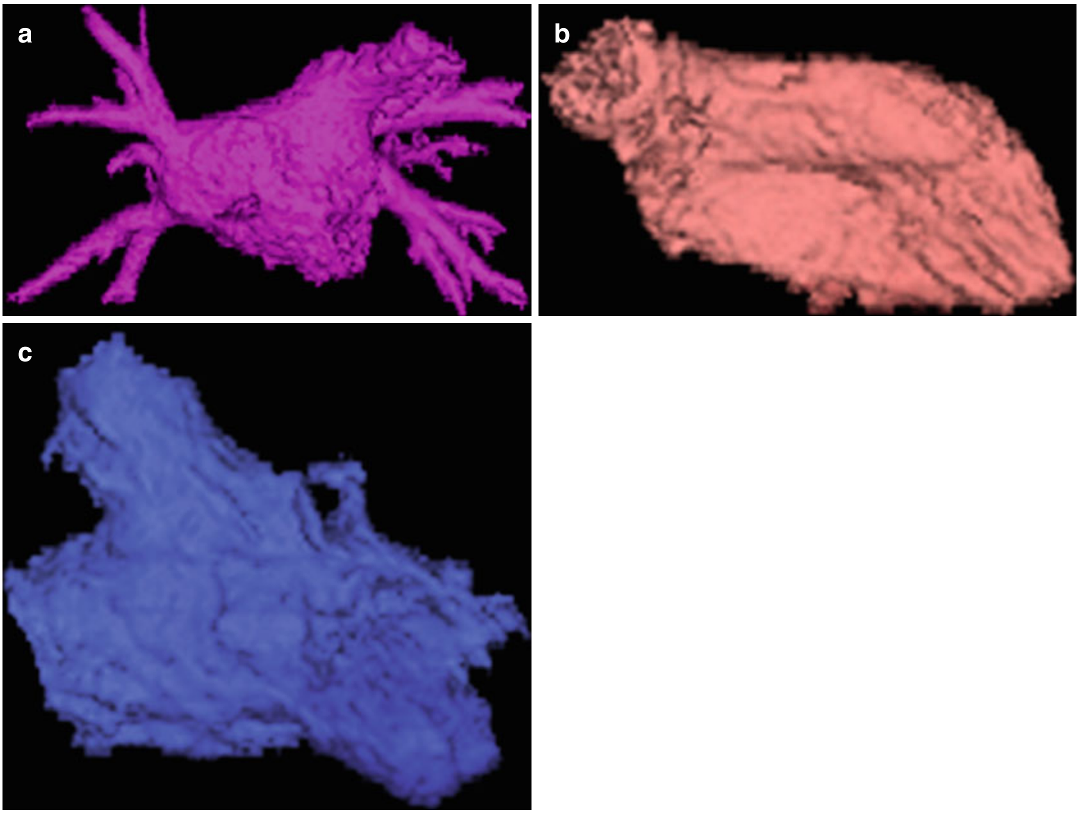

Fig. 3.5 *Pink* is used for the pulmonary veins (**a**), *salmon* for the left ventricle (**b**), and *violet* for the right ventricle (**c**)

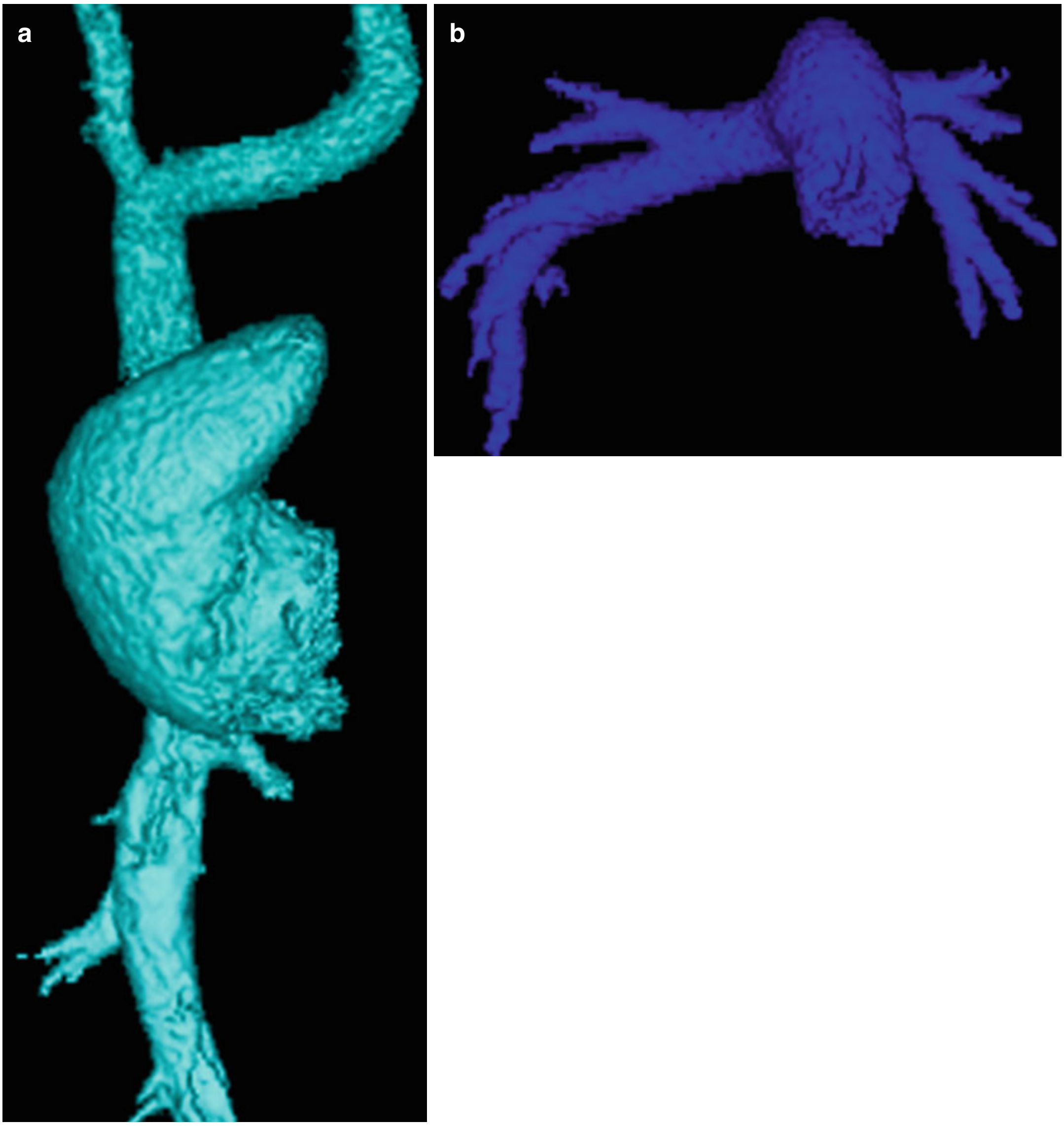

Fig. 3.6 (**a**) The right atrium and systemic veins are colored *light blue*. (**b**) The pulmonary artery appears *dark blue*

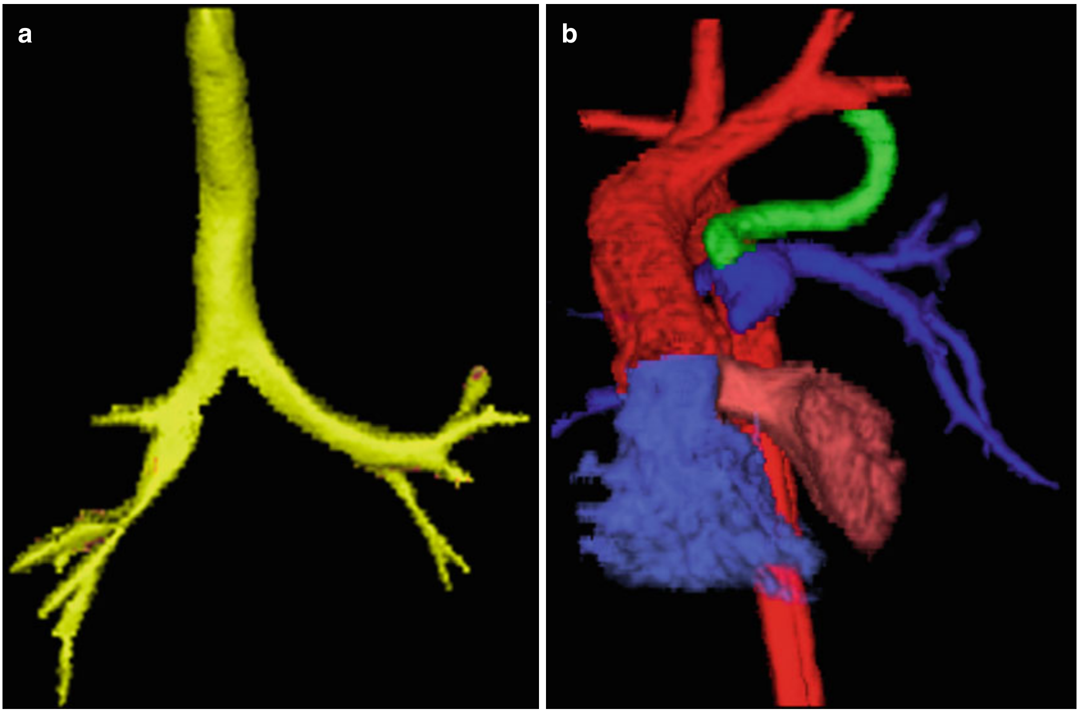

Fig. 3.7 (**a**) The trachea is colored *yellow*. (**b**) Surgically created shunts and patent ductus arteriosus are *green*

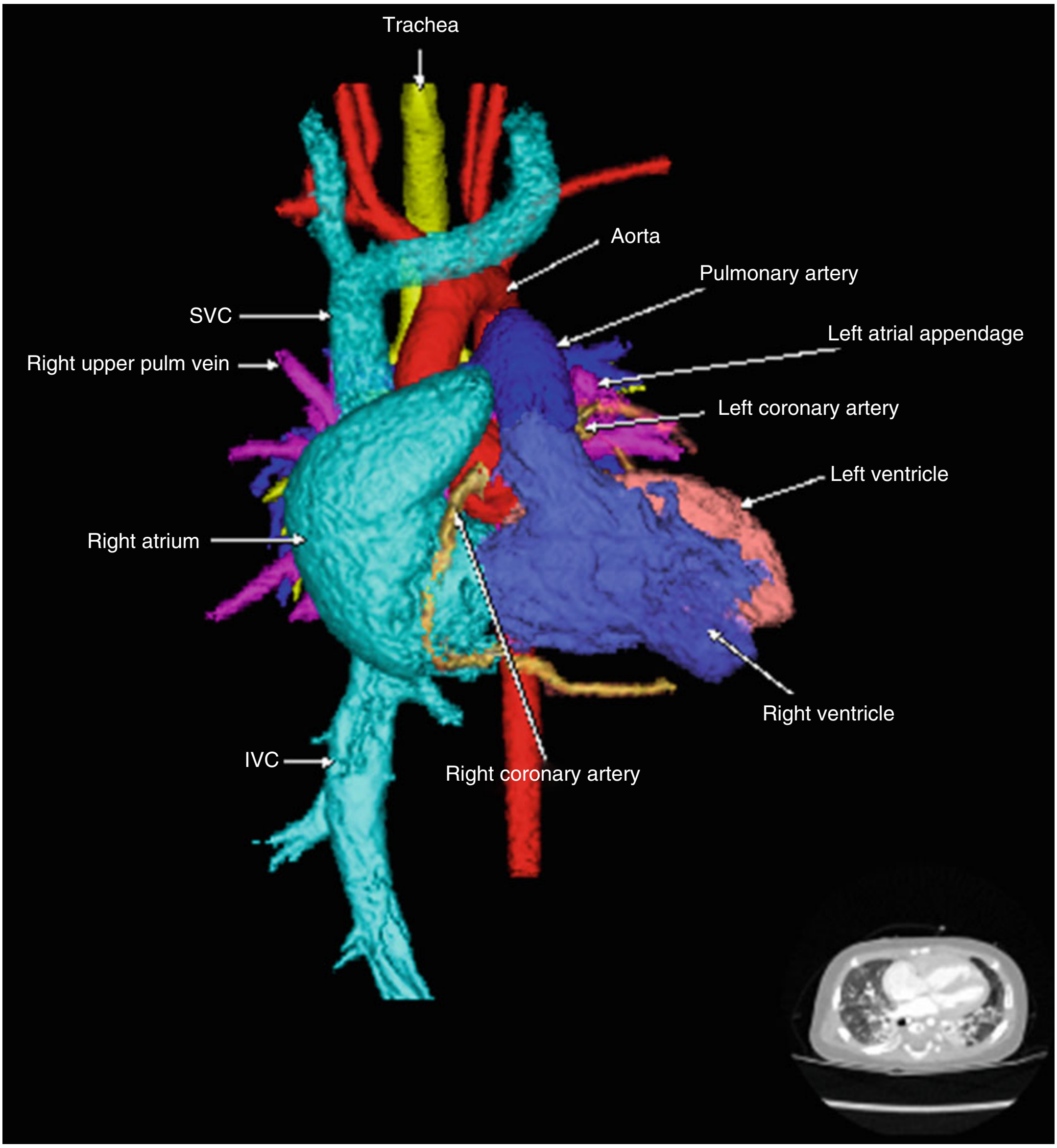

Fig. 3.8 The individual structures are then pieced together to create the full color-coded 3D model, which can be sent to the picture archiving and communication system so health care providers can understand the patient's anatomy. *IVC* inferior vena cava, *SVC* superior vena cava

Color-Coded Resin Models

Once the segmentation and coloring of the models are complete, the data exist to create an actual 3D resin model of the anatomy. A 3D rapid prototyping machine may be used to create models of the heart. These models are to scale and may be sterilized and used in the operating room (Fig. 3.9).

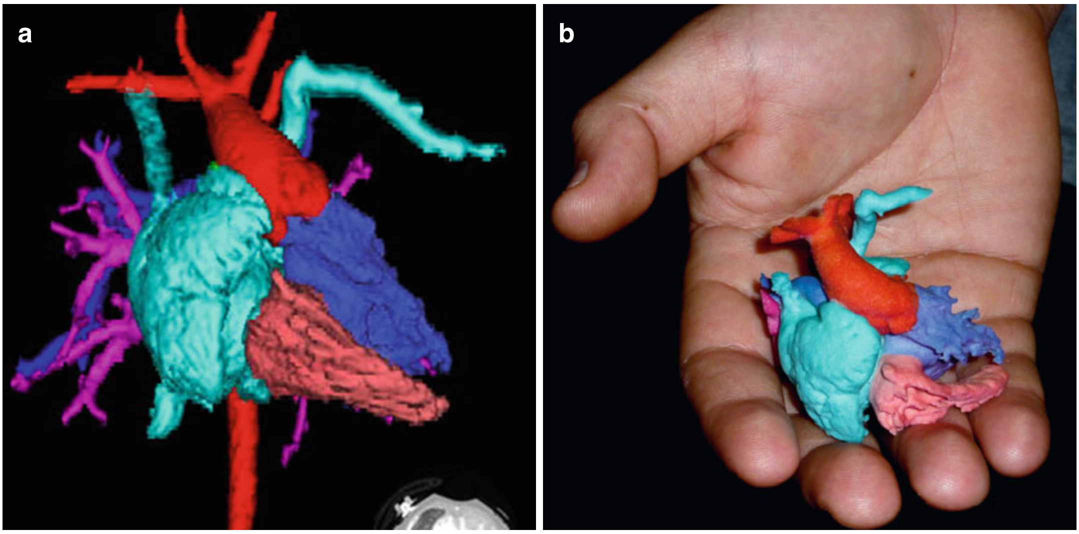

Fig. 3.9 A frontal projection color-coded 3D model (**a**) and a 3D resin model (**b**) of the same anatomy. In the future, these color-coded models may be created using synthetic materials to provide a realistic texture of the patient's anatomic defects. This might allow for improved training and the sharing of complex surgical and angiographic techniques for patients with complex congenital heart disease