There can be little doubt that the cross-sectional echocardiographer will be tomorrow’s anatomist. The level of discrimination of modern day echocardiographic machines is such that all but the finest details of cardiac structure are revealed in real time. Advances in three dimensional reconstruction now amplify the information obtained, and make it more amenable to clinical interpretations. It remains true, nonetheless, that the information available to the echocardiographer will be more accurately interpreted if the investigator has a good working knowledge of cardiac anatomy. This is not difficult to obtain. The basic rules and principles are exactly as we set them out in 1983.1 As with any three dimensional structure, so as to determine the interrelationships of the cardiac components, it is necessary to obtain details as seen in the three orthogonal planes. These planes, at right angles to each other, are the equivalent of the floor plan, the frontal elevation, and the side elevation of any building. When considering the heart, however, the information obtained must be interpreted taking account of the fact that the orthogonal planes of the heart itself are very maligned relative to the orthogonal planes of the body. The steps involved in gaining the basic knowledge, therefore, are to begin by reviewing the orthogonal planes of the body. It is then essential to understand the usual position of the heart within the body, along with the orientation of its own orthogonal planes. Thereafter, it is necessary to understand the usual positions of the cardiac chambers and valves within the cardiac silhouette. The basic anatomic information must then, self-evidently, be understood in sectional format. There are, of course, no standard sections which will always deliver the necessary information, since no two individuals have exactly identical relations of the cardiac components. So, it is not always possible to reveal cardiac structure using “standard” echocardiographic windows. The skilled echocardiographer will use any section, obtained from any echocardiographic window, to delineate the desired findings. It helps, nonetheless, to illustrate certain typical sections. The focus, however, should not be on obtaining the given section, but rather on demonstrating the required anatomy.

Anatomic position

Structures within any part of the body are traditionally described on the basis that the subject is standing upright and facing the observer (fig 1). Within the body as thus seen, there are three basic orthogonal planes. Two are in the long axis of the body. One of these cuts the body from right to left, and produces sections in the frontal, or coronal, plane. The second plane along the long axis cuts from the front, or anterior, to the back, or posterior. This is the sagittal plane. These are, of course, any number of frontal and sagittal planes, each at right angles to the other. There are then infinite intermediate planes in the long axis, but no single one is at right angles, and hence also orthogonal. Instead, the third series of orthogonal planes is in the short axis. This series extends from the head, or superiorly, to the feet, or inferiorly. Any number of intermediate planes are similarly to be found between each of the short axis and the long axis planes, but none of these is orthogonal. It is knowledge of the three basic orthogonal planes which is sufficient to build up the three dimensional configuration of the body.

Location of the heart

The heart lies in the middle mediastinal compartment of the thorax, enclosed within its pericardial sack, and sandwiched between the two pleural cavities. When projected to the...
The biggest problem to be overcome in understanding cardiac anatomy is to appreciate that the adjectives “right” and “left” are used impropriately when describing the cardiac chambers. In reality, the so-called “right” chambers are more-or-less anterior to their purported left sided counterparts, while the atria are essentially to the right of their respective ventricles. Thus, in the frontal silhouette, it is the right atrium and right ventricle which occupy most of the cardiac surface (fig 3). Viewing the heart from its apex, corresponding to the left anterior oblique angiographic projection (fig 4), then reveals the crucial interrelation of the cardiac valves. The pulmonary trunk is the most superior valve, with the leaflets supported on the free standing muscular infundibulum. The tricuspid valve is the most anterior valve, but is also the most inferior. The aortic valve forms the centrepiece of the heart, and is located directly in front of, and just above, the mitral valve. The leaflets of the aortic and mitral valves are in fibrous continuity, a feature of crucial importance in understanding the complications of endocarditis of the aortic root. Via the substance of the membranous part of the septum, the aortic valvar leaflets are also in continuity with those of the tricuspid valve. When seen in the frontal silhouette, only a thin strip of left ventricle projects to the cardiac margin, and only the appendage of the left atrium is visible. This is important information for the echocardiographer, since it means that, if approached anteriorly, it is necessary to traverse the cavities of the right atrium or ventricle before it becomes possible to interrogate the left sided structures.
heart to be cut along its own long or short axes. From each window, the heart can be cut in only two of the orthogonal planes, albeit that multiple intermediate planes can be obtained. Once again, nonetheless, it is knowledge of the images obtained in the orthogonal planes which provides the key to understanding. The parasternal windows, usually obtained from the third or fourth interspaces, permit the heart to be cut from front to back, and also in short axis. Traditionally, the slices from front to back are orientated as they would be seen in lateral projection, with the cardiac apex pointing to the left hand of the observer (fig 5). The short axis slices are orientated as they would be seen from inferiorly (fig 6). The long axis slice from front to back can also be obtained from the cardiac apex, but the apical window provides the crucial slice in which the heart is cut from side to side, giving the so-called four chamber section (fig 7). In fact, because of the deeply wedged location of the aortic root, most sections obtained from the cardiac apex which slice the heart from right to left also cut through the aorta, giving the so-called “five chamber” cut (fig 8). These cuts show well the arrangement of the septal components, particularly the membranous septum, which forms an integral part of the aortic root. For traditional reasons, it is customary for echocardiographers dealing with adult subjects to display these “four chamber” sections as though the patients are standing on their head. There seems no logical reason to continue this practice, other than familiarity, since echocardiographic machines permit the operator to produce the images in whatever orientation is desired. Correlations with other imaging modalities, and with anatomy itself, are surely facilitated if the images are shown in attitudinally appropriate fashion.

The other echocardiographic windows permit the heart to be cut in the orthogonal planes of the body. Thus, from subcostal position the heart can be sliced in paracoronal and parasagittal fashion. Similar slices, and intermediate planes, can be obtained from the suprasternal
Information obtained from these windows supplements that obtained using the parasternal and apical windows, and is particularly valuable for the echocardiographer examining neonates and infants with congenitally malformed hearts. The basic knowledge concerning the overall cardiac structure, nonetheless, is usually obtained from the classical windows. Using these limited points, it is usually possible to obtain information concerning not only the dimensions and structure of the chambers and valves, along with the outflow tracts and the arterial trunks, but also the origins and patency of the proximal coronary arteries. By combining cross-sectional examination with Doppler interrogation, it is also possible to reveal the patterns of the flow of blood throughout the heart. With the advent of harmonic and contrast imaging, the patterns of contraction of the ventricles can be determined, permitting recognition of subtle abnormalities of wall motion.

Echocardiography, without doubt, is an immensely and increasingly powerful tool. To take full advantage, it helps if the investigator is fully conversant with the detailed structure of the heart, particularly such features as the precise arrangement of the atrial septum (fig 9), the origin and proximal course of the coronary arteries (fig 10), and the structure of the aortic root.1 Detailed descriptions of these features are beyond the scope of this brief review, but the structure of the atrial septum will be addressed in a subsequent article in this series of anatomic reviews. The simple rules as set out here, nonetheless, should provide the information needed to display the echocardiographic manifestations of clinically significant cardiac structure.

Professor Anderson is supported by the Joseph Levy Foundation and he and Dr Ho are supported by the British Heart Foundation.
   - This review, now nearly 20 years old, sets out the philosophy summarised in the current article. Nothing has changed in the meantime, except that the echocardiographic machines are now much more powerful, and demonstrate the anatomy in even greater detail.

   - This article sets out the obvious, but highlights a problem that we had ignored even though, for many years, we had professed to illustrate the heart as seen by the clinician. We had failed to observe that the terms used to describe the heart reflects its position as standing on its apex, rather than its true position within the thorax. This means that there is, in general, a deficiency of almost a right angle in current descriptions. Those structures presently said to be “anterior” are, in reality, superior, and so on. The article emphasises the deficiencies of the current approach for the electrophysiologist, but they are equally applicable to description of the coronary arteries.

   - This review was the forerunner to this article in our contributions to “Education in Heart”. We discussed the structure of the aortic root, emphasising clinical features, and pointing to problems in defining the enigmatic “annulus”.

www.heartjnl.com
Anatomic basis of cross-sectional echocardiography

Robert H Anderson, Siew Yen Ho and Stephen J Brecker

*Heart* 2001 85: 716-720
doi: 10.1136/heart.85.6.716

Updated information and services can be found at:
http://heart.bmj.com/content/85/6/716

These include:

**References**
This article cites 3 articles, 3 of which you can access for free at:
http://heart.bmj.com/content/85/6/716#BIBL

**Email alerting service**
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

**Topic Collections**
Articles on similar topics can be found in the following collections

Clinical diagnostic tests (4779)
Echocardiography (2127)
Education in Heart (527)

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/