Editorial: How can we best describe the components of the mitral valve?

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It is, perhaps, surprising that, as we progress well into the 21st century, we still debate how best to describe the anatomic features of the mitral valve. Indeed, we could extend our comment to all of the cardiac valves, since there is still no consensus as to which structure represents the "annulus" of the arterial valves (1-3). This specific editorial comment, however, concerns the detailed anatomy, and most appropriate description, for the aortic, or anterior, leaflet of the mitral valve. Our comments are also tinged with a significant degree of sadness, since during the review of the article addressed by our comments (4), its senior author, Solomon Victor, died subsequent to acute myocardial ischaemia.

We should start our commentary, therefore, by acknowledging the significant achievements of Solomon, and his associate Vijaya Nayak, who remains to continue his pioneering investigations. Those with an overwhelming interest in the surgical anatomy of the heart are becoming increasingly rare, and we can ill afford to lose any of them. Solomon, nonetheless, had enjoyed a relatively long career in the field of cardiac surgery, and it is encouraging to know that Vijaya is determined to extend his findings, and continue his quest to widen the knowledge of not only surgical, but also comparative cardiac anatomy. Any study of comparative anatomy, however, and any comparisons with the formed and developing human heart, needs to be based on the latest findings concerning cardiac development.

The advances made in understanding the mechanics of development over the past decade are huge. It is no longer acceptable to depend on accounts appearing in standard textbooks of embryology, particularly when they are based on the concept of an initial linear heart tube containing the primordiums of all the definitive cardiac chambers. We now know that the components of the pulmonary circulation, specifically the right ventricle and the pulmonary veins, are added to the linear heart tube during its own development, with the initial straight tube forming the basis of little beyond the left ventricle (5,6). Studies of comparative anatomy, and more so, comparative cardiac development, can certainly enhance our knowledge of how the components of the pulmonary circulation come to be added to the relatively simple heart of species such as bony fishes. The hearts of turtles, for example, possess an incomplete right ventricle, albeit with three arterial trunks arising from the ventricular outflow tracts. The hearts of crocodiles and alligators are even more fascinating, in that they have completely septated ventricles, still with three arterial trunks, and with a communication between the right and left ventricular aortas at the level of the arterial roots. Solomon Victor was deeply inquisitive about these remarkable findings, and believed they may help us understand the congenitally formed human heart. This may, indeed, prove to be the case. It would be foolish to imagine, however, that the hearts of the turtle and crocodilians could be compared directly to lesions such as double inlet ventricle, or aorto-pulmonary window. The great Maude Abbott was much impressed by Spitzer's theory of the right ventricular aorta of reptiles persisting in congenitally malformed hearts as the transposed aorta (7), but we have long since abandoned this concept. Whilst we can learn much from examination of comparative anatomy, we must be careful as to how much we extrapolate from the findings to human cardiac anatomy.

The current study of Nayak and Victor (4), nonetheless, addresses a crucially important issue, namely the structure of the aortic leaflet of the mitral valve. The aortic leaflet of the mitral valve attracts far less surgical attention than does the mural, or posterior, leaflet. Most reparative operations are carried out on the mural leaflets. It was a previous study from Victor and

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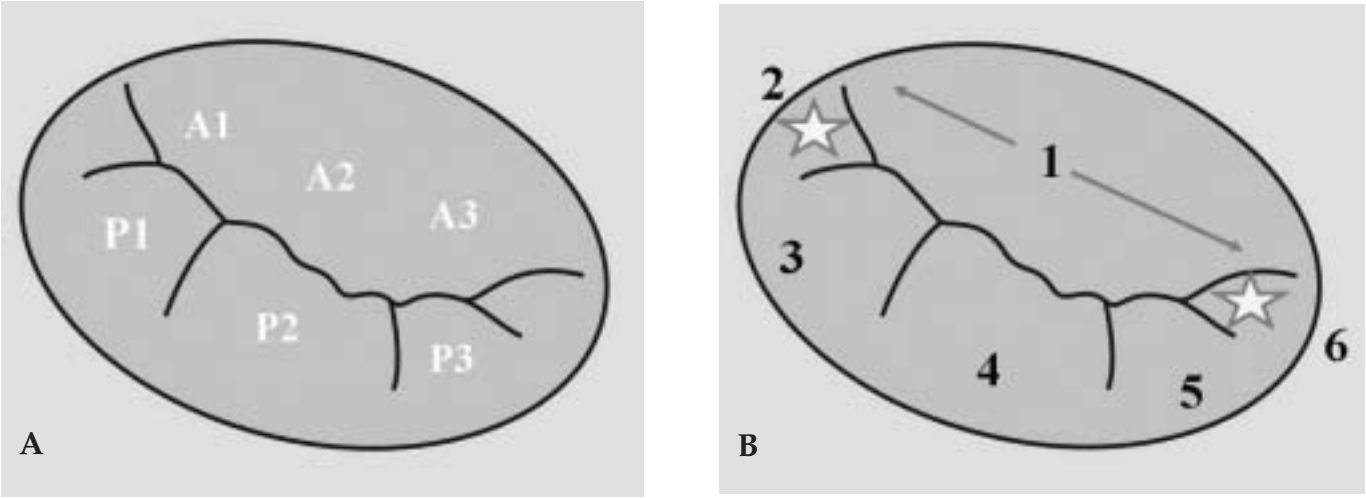

Figure 1. The cartoons show the atrial view of the mitral valve shown in Figure 2. The panel to the left hand shows the components of the valve recognized by Carpentier[9], with 3 scallops in the mural leaflet, and 3 facing components of the aortic leaflet. The panel to the right hand shows the alternative system for description suggested by Kumar and colleagues[10], in which the so-called "commissural" leaflets, shown by the stars, are recognized as discrete parts of the valve, giving 6 components in all to the valve, as recognized by Carpentier, but with 5 belonging to the mural leaflet.

Nayak (8) that clarified the surgical significance of the mural leaflet. Arguments still continue as to whether this component of the valve should be analyzed according to the three parts recognized by Carpentier (9) (Figure 1a), or the five parts suggested by Kumar and associates (10) (Figure 1b). The reason for the discrepancy in the two approaches is that the solitary zone of apposition between the two major parts of the skirt of leaflet tissue guarding the left atrioventricular junction does not extend to the annulus. Thus, when the normal valve is viewed in its closed position (Figure 2), additional segments of leaflet can be recognized over and above the "scallops" defined by Carpentier (9), and now firmly entrenched in the surgical lexicon as "P1", "P2", and "P3".

The earlier study of Victor and Nayak (8), however, emphasized that one size does not fit all, and that not even all normal valves can adequately be categorized within the classification of Carpentier (9). As they showed, the mural leaflet of the normal valve fits against the aortic leaflet when the valve is in its closed position, with sufficient slits along the more extensive leaflet to permit snug and competent closure. They have now extended their analysis to examine the detailed structure of the aortic leaflet (4).

Again, they emphasize the variability to be found in the precise structure of the leaflet, particularly its ventricular surface. They remind us of the exquisite drawings made by Leonardo da Vinci to show the steps and arches on this ventricular surface. They point out that, like the fingerprints, the arrangements of these steps and arches are unique to each individual. The importance of these "strut", "stay", or "load bearing" cords, which Nayak and Victor prefer to describe as "belly" cords, has also been stressed recently in regard to the left atrioventricular valve in patients with atrioventricular septal defect and common atrioventricular junction (11). Repair of this valve has always been, and remains, the Achilles heel of surgical correction. It is surely significant, therefore, that the reconstructed valve in atrioventricular septal defect of necessity lacks the organized steps and arches described for the normal mitral valve, and illustrated so long ago by

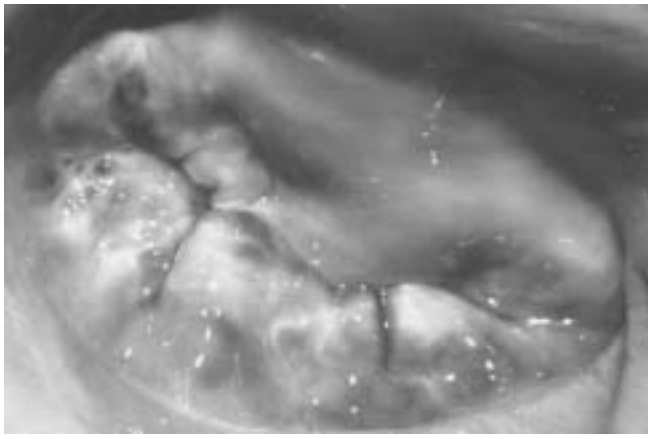

Figure 2. This view of the atrial aspect of the closed mitral valve, taken by Dr Van G. Galstyan from Armenia, and reproduced with his permission, shows how a competent valvar mechanism is dependent on the existence of a solitary zone of apposition between the aortic and mural leaflets, which guard markedly dissimilar components of the atrioventricular junction. It is the presence of slits in the larger, mural, leaflet that permits snug closure of the overall valvar apparatus.

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Figure 3. The cartoon shows the positions of the papillary muscles of the mitral valve as seen in left anterior oblique projections. The sternum, at the front of the chest, is shown to the left hand, whilst the spine is seen to the right hand. It is readily evident that the so-called "postero-medial" muscle is inferior and septal, whilst the alleged "antero-lateral" muscle is superior and parietal. We suggest that surgeons might best recognize the muscles as being right and inferior, and left and superior.

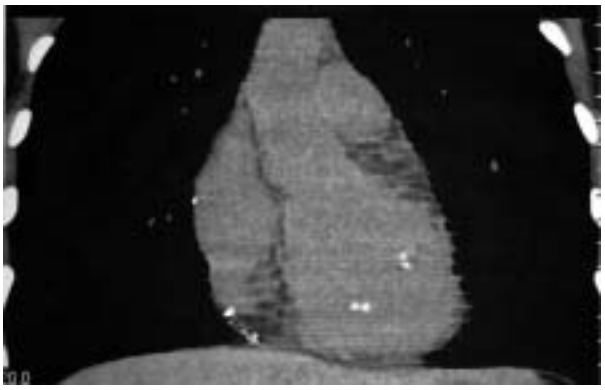

Figure 4. A sagittal section of a human heart from a multislice computerised tomographic scan. Two pairs of synthetic felt pledgets placed on the papillary muscles show up on the scan in the region of the left ventricle and reveal that the muscles are clearly left superior and right inferior. From reference 12.

Leonardo, since the malformed valve has never been a mitral valve, and despite the best efforts of the most skilled surgeons, can never become a normal mitral valve.

The other important part of the discussion of Nayak and Victor (4) is that they question the way we have previously described the valve. In most accounts, we still find the papillary muscles described as being "postero-medial", and "antero-lateral". The recent advent, and rapid acceptance, of tomographic techniques for diagnosis, however, has restored the heart to its appropriate position within the body. These techniques emphasize that, for years, morphologists have disobeyed the cardinal rules of anatomy when describing the relationships of the components of the heart. This is because, irrespective of the organ being described, and irrespective of the posture of the individual being described, convention dictates that all structures should be described in the anatomical position, with the subject upright and facing the observer. Generations of cardiac anatomists and pathologists, however, have removed the heart from the body, and described it as though standing on its own apex. It is only in this orientation that the papillary muscles of the mitral valve become "postero-medial" and "antero-lateral". When considered in attitudinally appropriate fashion, the muscles are positioned inferoseptally and supero-parietally (Figure 3). For the surgeon, these terms are not immediately intuitive, and we would suggest that the most appropriate, and correct, descriptors would be right inferior and left superior (12). Time will tell as to which terms are adopted by the surgical community, and usage will be the final arbiter, but common sense dictates that structures should be described as they are seen during diagnostic maneuvers, and most diagnostic techniques now show the heart as it lies within the body (Figure 4).

In conclusion, therefore, we welcome the latest episode from the anatomic school nurtured by Solomon Victor. We are dismayed that Solomon himself will no longer be present to lead the school forward, but we are sure that much more will follow from Vijaya Nayak, with the future studies hopefully placing comparative anatomy in the appropriate context of cardiac development and the surgical anatomy of the heart.

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