CHAPTER 26 POSTERIOR LEAFLET PLEATS AND SCALLOPS

In Chapter 25 we noted that the posterior leaflet regions in the vicinity of Markers #5 and 6 and #9 and 11 were undergoing consistently large dimensional changes with valve opening and closing in each of the three hearts studied, and thus might be considered as prime candidates for the large changes of the posterior leaflet perimeter throughout the cardiac cycle. In this chapter we explore the kinematics of these regions in greater detail. Again, we provide Figure 26.1 as a reference for marker placement in these studies.

Markers #5 and 6 are near the P1-P2 junction. Figure 26.2A illustrates the relative position of the markers in this region in the widely open valve and Figure 26.2B their position in the closed valve. Figures 26.2A and B are two frames from an animated sequence provided in Appendix E for a complete cardiac cycle in heart COM07R04.

In Figures 26.2A and B, Marker #17 is identified with a filled black symbol, Marker #3 with a filled blue symbol, Marker #5 with a filled green symbol, Marker #6 with a filled red symbol, and Marker #4 (at the nearby anterior leaflet edge) with a black-bordered yellow symbol. The continuous black curve is a cubic spline through the annular markers, the red curve is a cubic spline through the anterior leaflet edge markers, and the blue curve is a cubic spline through adjacent posterior leaflet edge markers as shown in Figure 26.1. The triangle bounded by Markers #5-6-17 is filled in red and the triangle bounded by Markers #3-5-17 is filled in blue. All features of the 4 panels in each figure are as described in Chapter 24; Figures 26.2A and B are a closer study of the specific P1-P2 region of the posterior leaflet.

Markers #9 and 11 are near the P2-P3 junction. Figure 26.3A illustrates the relative position of the markers in this region in the widely open valve and Figure 26.3B their position in the closed valve. Figures 26.3A and B are also two frames from an animated sequence provided in Appendix E for one complete cardiac cycle in heart COM07R04.

In Figures 26.3A and B, Marker #19 is identified with a filled black symbol, Marker #9 with a filled blue symbol, Marker #11 with a filled green symbol, Marker #12 with a filled red symbol, and Marker #10 (at the nearby anterior leaflet edge) with a black-bordered yellow symbol. Again, the continuous black curve is a cubic spline through the annular markers, the red curve is a cubic spline through the anterior leaflet edge markers, and the blue curve is a cubic spline through adjacent posterior leaflet edge markers as shown in Figure 26.1. The triangle bounded by Markers #11-12-19 is filled in red and the triangle bounded by Markers #9-11-19 is filled in blue. All features of the 4 panels in each figure are as described in Chapter 24; Figures 26.3A and B are a closer study of the specific P2-P3 region of the posterior leaflet.

Animations from two other hearts, COM02R02 and COM06R01, are also provided in Appendix E.
These four figures strongly suggest that the P1-P2 and P2-P3 junctions are capable, almost entirely, of providing the large change in posterior leaflet perimeter needed to open the valve widely during left ventricular filling and close it tightly during ejection. In many respects, these regions provide junctions similar to pleats, commonly used to gather a wide piece of fabric to a narrower circumference. In this case, these posterior leaflet pleats are greatly flattened during diastole and gathered tightly during systole.

Note that these data provide only a rough idea of pleat geometry because our widely-spaced markers were placed in flaccid hearts under cardiopulmonary bypass without precise knowledge of pleat geometry. Although dozens more markers would be needed to precisely characterize each pleat, these data allow an improved understanding of a possibly important mechanism employed to allow large changes in the mitral orifice throughout the cardiac cycle.

Along with potential chordal guidance, the scalloped geometry of the P1, P2, and P3 regions of the posterior leaflet may be important to assure that the pleats fold and unfold in an appropriate manner with each beat. The greater surface area at mid-scallop would allow greater force to be exerted from LV pressure gradients during IVC at mid-scallop than at the pleats, thereby preventing a potentially disastrous inversion of pleat geometry that would impede valve closure.
Although the changing dimensions of the P1-P2 and P2-P3 regional pleats may dominate the perimeter expansion and contraction of the posterior leaflet during the cardiac cycle, the data shown in Figures 25.5, 25.6, and 25.7 suggest that a number of other sites (highlighted in red in these Figures) may also be folding and unfolding to provide additional perimeter changes. Again, a future study with much greater spatial resolution than the present study would be needed to elucidate the importance of these additional folds. The severe folds at the commissural scallops adjoining the left and right fibrous trigones are of considerable interest in this regard.

Finally, it should be recognized that any folded pleats in the closed valve will be pressed tightly together by systolic left ventricular pressure acting on their outer (ventricular) surfaces (i.e. the outer surfaces of both the red and blue triangles in Figures 26.2B and 26.3B). This provides a rib-like structure that may help stiffen the posterior leaflet to help the valve resist systolic deformation.