CHAPTER 18 ANNULAR & LEAFLET SHAPE AND PLANARITY

Annular shape change in each heart was quantified by fitting (as described in Appendix C) a best-fit plane to all annulus markers (#15-#30) for each frame (f) during the three consecutive beats studied. The distance (Z) from each annulus marker (m) to this plane in each frame Z(f,m) was then obtained and the standard deviation of Z(f,m) computed for that frame as ZSD(f). This process was repeated for just the contractile annulus markers (#16-#20; #24-#29). A systolic average, Zavg(m), was then obtained for all annulus markers using all frames from mitral valve closing (MVC) to opening (MVO) for all three beats. For each frame, and each marker, the difference Z(f,m)-Zavg(m) was then computed and squared. The square root of the mean of these differences for all markers was then obtained for each frame as Zrms(f).

Figure 18.1 plots Zrms(f) vs. Frame for the three consecutive beats studied in each of the six hearts (H1-H6). Note that the full range of the ordinate is 0 - 1 mm in each graph. At the beginning of each beat, the mitral annulus is rapidly driven towards its mean systolic shape by the increase in LVP during IVC, starting immediately with the rapid LVP increase, continuing during and after mitral valve closure, and reaching a minimum in mid-to-late systole. Figure 18.1 shows that the shape of both the mitral annulus and the anterior leaflet (previously shown in Figure 9.1) are remarkably constant throughout systole in each beat and both exhibit sub-millimeter beat-to-beat repeatability. Annular shape begins to be driven back towards its diastolic value as LVP falls during the last half of IVR but before mitral valve opening. During systole, annular shape is dictated principally by LV pressure, not LV volume. During diastole, annular shape is dictated principally by LV volume, not LV pressure.

Figure 18.2 shows that the complete mitral annulus (trigone region plus contractile annulus) increasingly flattens throughout diastole, reaching its flattest configuration at the onset of the LVP increase at the beginning of each beat. It immediately becomes more curved in concert with the rising LVP during IVC, reaching its maximum curvature in mid-to-late systole then begins to flatten again in mid-to-late IVR as LVP falls. The contractile annulus, however, is much flatter than the complete mitral annulus and exhibits less curvature change throughout the cardiac cycle. This behavior is consistent with the concepts discussed in Chapter 17, where the annulus is described as consisting of two (nearly) independent parts, a fairly rigid trigone region hinged at an acute angle to an almost flat contractile region. The change in complete annulus flatness throughout the cardiac cycle is thus seen to be brought about primarily by the relative rotation of the contractile annular plane with respect to a trigone annular plane.

Note, in Figure 18.2, that complete mitral annular and anterior leaflet dynamics exhibit similar time-courses during IVC and IVR, but these dynamics are poorly correlated during filling and ejection. This emphasizes a point to be made repeatedly in this book; that the mitral annulus and anterior leaflet are almost independent entities, joined only at the trigonal hinge region around which both the annulus and anterior leaflet rotate.
Figure 18.1 Mitral annulus (blue) and anterior leaflet (red) ZRms for hearts H1-H6. LVP=Left Ventricular Pressure; Filled symbol during IVC=Mitral Valve Closure; Filled symbol during IVR=Mitral Valve Opening. See Text.
Figure 18.2 Z SD's for complete mitral annulus (Markers #15-#30, blue), contractile mitral annulus (Markers #16-#20; #24-#29, green), and anterior leaflet (Markers #15, #21-#24, #29-#30, #38-#53, red) for hearts H1-H6. LVP=Left Ventricular Pressure; MVC=Mitral Valve Closure; MVO=Mitral Valve Opening. See Text.