CHAPTER 04 ANTERIOR LEAFLET TRAMPOLINES

In Chapter 03 we asked what the anterior and posterior strut complexes were doing. In this chapter, we explore one of their likely functions. In future chapters, we examine additional functions.

A trampoline is a device that stretches a material taut with forces from peripheral radial springs. Here, we suggest that one of the functions of the anterior and posterior strut complexes is to stretch two anterior leaflet regions into a specific taut configuration at a specific time in the cardiac cycle.

Figure 4.1 displays data from a representative beat from heart H1 to illustrate these two regions (contained within the red outlines superimposed on the anterior (ANTERIOR) and posterior (POSTERIOR) halves of the anterior leaflet) and the time interval (from the onset of rapid left ventricular pressure rise (LVPO, top row) to the time of mitral valve closure (MVC, bottom row)). Leaflet color coding shows the displacements (mm) above (red) or below (blue) the planes defined by the Saddlehorn (#22), LFT (#29), and APT (#31) for the ANTERIOR half of the leaflet (left column), and the Saddlehorn (#22), RFT (#24), and PPT (#33) for the POSTERIOR half of the leaflet (right column). Note that, in spite of the much greater displacements of the leaflet edges, the anterior leaflet regions associated with the strut chordae (approximated by the areas contained within the red line boundaries) are maintained within roughly ±1mm of these respective planes immediately before the onset of rapid left ventricular pressure rise.

Figures 4.2a, b, and c show these same data for representative beats from hearts H1-H6 at the times of LV peak inflow (top row), onset of rapid LVP rise (second row), mitral valve closure (third row), and LV peak outflow (bottom row. As in Figure 4.1, in these hearts the two regions associated with their respective strut chordae are very little displaced from these respective chordal planes at the onset of rapid LVP rise and mitral valve closure.

These findings lead us to suggest that the strut chords, coupled with their trigone regions, serve to provide sufficient traction to guide these two regions of the anterior leaflet into prescribed geometric configurations immediately prior to the onset of the rapid LVP rise at the beginning of each beat.

Recall that Salisbury et al. showed that this traction is about 12 grams (0.12N) during diastole, with the struts never slacking. While this force is so small as to seem almost negligible, it is sufficient to pull these regions of the leaflet into these specific positions during diastasis when there are few other forces on the anterior leaflet; LVP is low, the valve is open (with nearly the same pressure on both anterior leaflet faces), and LV inflow is almost zero. The idea of such an “equilibrium” diastolic leaflet position associated with chordal traction is not new. It has been a classic subject of investigation, as summarized many years ago by Binkley et al. What is new here is the idea that this traction sets the geometry of specific regions of the anterior leaflet into a specific geometric configuration just before the valve closes.

What is the significance of guiding these regions into this specific geometry? We explore an answer to this question in the next two chapters.

REFERENCES
Figure 4.1. Anterior leaflet regions (within red outlines) that are stretched taut from the onset of LVP rise (LVPO) to mitral valve closure (MVC) for a representative beat from heart H1. Anterior leaflet color code is mm above (yellow-red) or below (green-blue) a plane defined by the saddlehorn marker (#22), LFT marker (#29), and APT (#31) for the Anterior half of the leaflet (left column), and a plane defined by the saddlehorn marker (#22), RFT marker (#24), and PPT (#33) for the Posterior half of the leaflet (right column). Black lines represent a first approximation of strut chord force vectors from the trigone region to the papillary tips (APT on the left, PPT on the right).
Figure 4.2a. Data from hearts H1 (left two columns) and H2 (right two columns). Anterior leaflet displacement (mm) above (yellow-red) or below (green-blue) planes defined by the saddlehorn marker (#22), LFT marker (#29), and APT (#31) for the Anterior half of the leaflet (first and third columns), and the saddlehorn marker (#22), RFT marker (#24), and PPT (#33) for the Posterior half of the leaflet (second and fourth columns). Black lines represent a first approximation of strut chord force vectors from the trigone region to the papillary tips (APT on the left, PPT on the right). Top row=time of peak LV inflow; second row=onset of rapid LV pressure rise; third row=time of mitral valve closure; bottom row=time of LV peak outflow.
Figure 4.2b. Data from hearts H3 (left two columns) and H4 (right two columns). Anterior leaflet displacement (mm) above (yellow-red) or below (green-blue) planes defined by the saddlehorn marker (#22), LFT marker (#29), and APT (#31) for the Anterior half of the leaflet (first and third columns), and the saddlehorn marker (#22), RFT marker (#24), and PPT (#33) for the Posterior half of the leaflet (second and fourth columns). Black lines represent a first approximation of strut chord force vectors from the trigone region to the papillary tips (APT on the left, PPT on the right). Top row=time of peak LV inflow; second row=onset of rapid LV pressure rise; third row=time of mitral valve closure; bottom row=time of LV peak outflow.
Figure 4.2c. Data from hearts H5 (left two columns) and H6 (right two columns). Anterior leaflet displacement (mm) above (yellow-red) or below (green-blue) planes defined by the saddlehorn marker (#22), LFT marker (#29), and APT (#31) for the Anterior half of the leaflet (first and third columns), and the saddlehorn marker (#22), RFT marker (#24), and PPT (#33) for the Posterior half of the leaflet (second and fourth columns). Black lines represent a first approximation of strut chord force vectors from the trigone region to the papillary tips (APT on the left, PPT on the right). Top row=time of peak LV inflow; second row=onset of rapid LV pressure rise; third row=time of mitral valve closure; bottom row=time of LV peak outflow.