A new concept for the treatment of mitral valve prolapse "Mitral Web": preliminary experimental study

Mitral kapak prolapsusu tedavisinde yeni bir yöntem "Mitral Ağ": Deneysel ön çalışma

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The mitral valve apparatus is a complex anatomic and functional unit composed of mitral annulus, valve leaflets, chordae, papillary muscles and underlying left ventricular wall. Normal function depends on both normal anatomy of each of these components and on the overall left ventricular size, shape and systolic function (1). Mitral regurgitation caused by abnormalities of many of these components can be corrected surgically with good long-term results. Instead of advancements of the surgical techniques, repair of mitral regurgitation caused by anterior valve or bileaflet valve prolapse is still a challenge for cardiac surgeons and the results are largely surgeon dependent (2,3).

All types of valve repair techniques save and correct the normal anatomy and function of the mitral valve, such as excision of the prolapsing segment, shortening of the elongated chordae or chordal creation instead of non-functional chordae. To date, only edge-to-edge repair is an exception, which constitutes a non-anatomic repair with double orifice mitral valve (4).

In this study, a new type of non-anatomic repair (mitral web) for mitral valve prolapse was studied in an experimental model. The concept of the mitral web is to prevent leaflet prolapse at the annular level by using polypropylene stitches or steel wire bars incorporated to the rigid annuloplasty ring.

Three bovine hearts were prepared. Left atrium was opened and four traction sutures were placed to the free edges of the left atrium, in order to have a free standing bovine heart model. A silicone tube was introduced into left ventricle via aorta and a purse string suture was tied over it to close the aorta to prevent leakage from left ventricle during filling (Fig. 1). Saline was injected into the left ventricle and closure and competency of mitral valve were observed by two independent observer.

In step 1, a "D" shaped rigid mitral annuloplasty ring was created by using double layer No. 5 sternal wires and it was covered with Dacron patch. Eight vertical and 5 horizontal bars were constructed with 2/0 polypropylene sutures inside the ring (mitral web I) (Fig. 1).

Posteromedial major chordae supporting the anterior leaflets were cut (chordal rupture model) and mitral valve was tested with saline injection into the left ventricle via the aortic tube. Prolapsus of the posteromedial side of the anterior leaflet and massive regurgitation were observed. Mitral web I, was implanted to the mitral annulus with interrupted horizontal mattress sutures. Left ventricle was filled again, but Mitral web I failed to prevent regurgitation. Closure line of the mitral valve leaflets was below the annulus level. Although prolapse of the anterior leaflet was prevented at the annulus level, significant regurgitation occurred between annulus level (mitral web level) and closure line of the mitral valve.

In step 2, vertical and horizontal convex shaped bars were constructed with no.1 sternal steel wires inside the same ring (mitral web II). Both anterolateral and posteromedial papillary muscles was resected from the left ventricular free wall. Both papillary muscles were reattached to the ventricular free wall 1 cm. above to the original site (bileaflet prolapse model). Mitral valve was tested with saline and bileaflet prolapse and massive regurgitation was observed. Mitral web II was implanted to the mitral annulus and tested by using the same technique. Mitral web II, prevented bileaflet prolapse below the annulus level close to the closure line (due to convex shape) and prevented regurgitant flow on a large scale. One cm. above reimplantation of the both papillary muscles provided a better model for bileaflet prolapsus or Barlow's disease. Levels of free edges of the both leaflets were above the annulus level. Mitral web II, brought anterior and posterior leaflets together close to the original closure line.

In step 3, four half-moon shaped bovine pericardial leaflet were incorporated with the mitral web 2, to cover the posterior leaflet area (mitral web III). Localization of these pericardial leaflets were just below to the bars of the web and above the mitral valve posterior leaflet. So, opening of the bovine pericardial leaflets were towards to the left ventricle passively and closing at the web level, was provided with support of the convex, steel bars of the mitral web.

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Anterolateral papillary muscle was resected and re-attached to 1 cm. above to the original site. This created prolapse of the anterolateral commissure site of the both anterior and posterior leaflets with normal appearing posteromedial site. Mitral web III was implanted and tested with the same technique. No regurgitation or leaflet prolapse was observed. Pericardial leaflets were closed together with the mitral valve at the same level below the mitral web (Fig. 1).

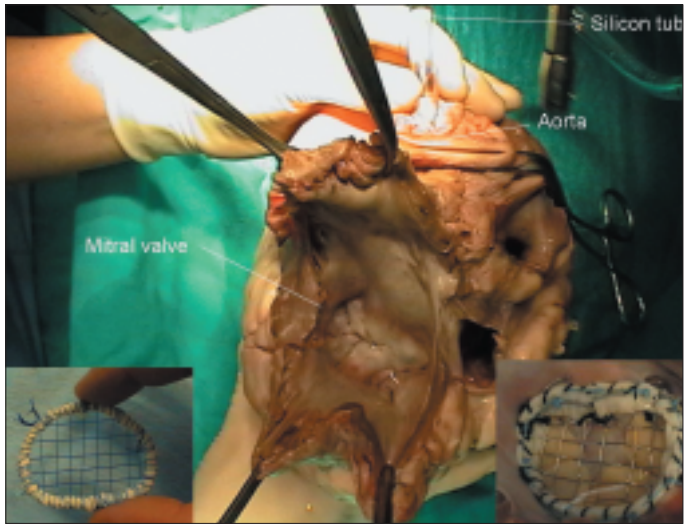

Figure 1. Set-up of the bovine heart model for experimental study. Mitral web I is at the left bottom part. Implanted mitral web III during ventricular filling is at the right bottom part. Closure of mitral valve anterior leaflet over pericardial leaflets of the mitral valve is prominent

Mitral web is a new concept for preventing mitral valve prolapse. With this concept, chordae tendinea and papillary muscle function may not be as important as in conventional repair techniques. A pliable, moving anterior mitral valve leaflet might be enough to repair every valve (Fig. 2). There are some questions to be solved about restriction of the blood flow, possible thromboembolic complications and damage to the mitral valve with the mitral web.

Although this preliminary study have several limitations such as the results relied solely on observation without quantitative data and an arrested heart model is largely different from beating hearts. The concept of the mitral web, might be a promising alternative technique to prevent mitral regurgitation. Mitral web may also provide easy, fast and non-surgeon dependent repair of the mitral valve, especially in minimally invasive procedures. In-vitro and in-vivo studies should be performed to evaluate the ideal design, efficacy and reliability of the mitral web.

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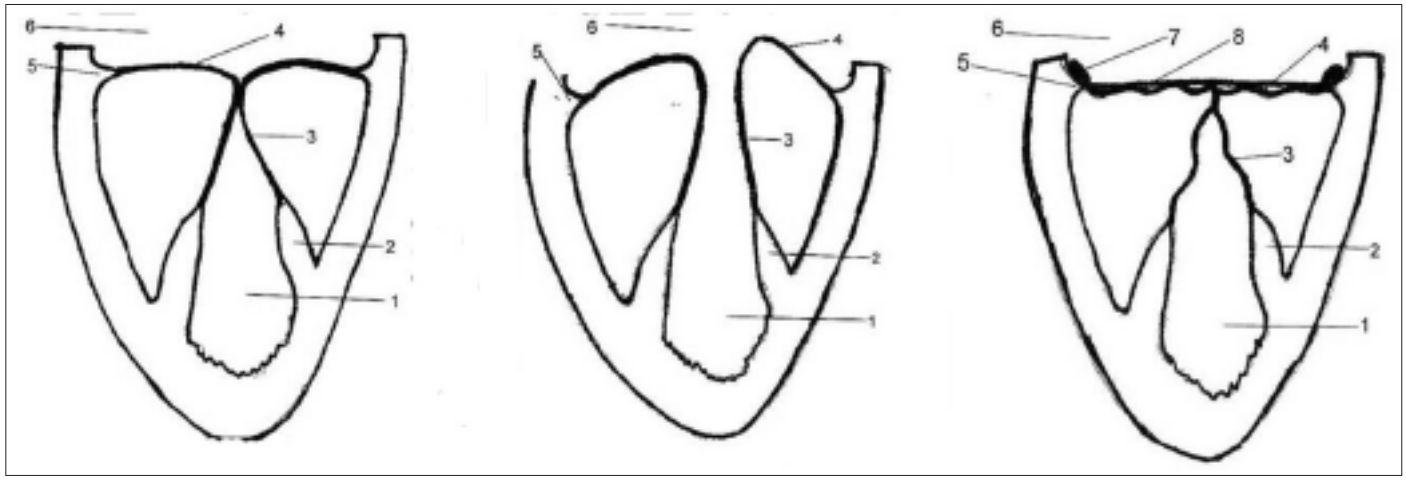

Figure 2. a) Normal mitral valve b) bileaflet prolapse c) after implantation of the mitral web. (1: left ventricle 2: papillary muscle 3: chordae 4: leaflet 5: annulus 6: left atrium 7: ring structure 8: web structure of the mitral web)