# Justification for Anti-Anatomic Positioning of Bileaflet Mechanical Mitral Valves

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April 05, 2024

**Abstract**

In the early 1980s, implantation of bileaflet mechanical mitral valves (MMVs) in the anatomical plane was found to be associated with incomplete closure of the posterior leaflet, resulting in a higher incidence of valve thrombosis. This phenomenon, coined as the "lazy" leaflet, was avoided with anti-anatomical orientation. This historical observation helped standardize the implantation technique, but variability in surgical practice for leaflet orientation persists. The latter might have been increasing since rotatable cuff designs became available on newer generation models of MMVs. Indeed, this feature makes it tempting to prioritize a perfect custom prosthetic fit at the expense of proper orientation. We present the case of a young woman with rheumatic mitral valve disease in whom an On-X MMV was rotated in the anatomical plane, resulting in a limited excursion of the posterior occluder. This case illustrates that anti-anatomical implantation should still be favored with new-generation MMV models.

**Justification for Anti-Anatomic Positioning of Bileaflet Mechanical Mitral Valves**

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**Running Title:** The "Lazy" Posterior Leaflet

**Conflicts of interest:** Nothing to disclose.

**Sources of funding:** None.

**IRB approval, consent statement and clinical trial registration:** N/A

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**Abstract:** In the early 1980s, implantation of bileaflet mechanical mitral valves (MMVs) in the anatomical plane was found to be associated with incomplete closure of the posterior leaflet, resulting in a higher incidence of valve thrombosis. This phenomenon, coined as the "lazy" leaflet, was avoided with anti-anatomical orientation. This historical observation helped standardize the implantation technique, but variability in surgical practice for leaflet orientation persists. The latter might have been increasing since rotatable cuff designs became available on newer generation models of MMVs. Indeed, this feature makes it tempting to prioritize a perfect custom prosthetic fit at the expense of proper orientation. We present the case of a

young woman with rheumatic mitral valve disease in whom an On-X MMV was rotated in the anatomical plane, resulting in a limited excursion of the posterior occluder. This case illustrates that anti-anatomical implantation should still be favored with new-generation MMV models.

## Introduction

When bileaflet mechanical mitral valves (MMVs) were first introduced in the 1970s, it seemed intuitive to position them in an anatomical orientation in an attempt to imitate nature[1]. However, in the early 1980s, cases of early valve thrombosis were observed[1]. Imaging studies suggested that these thrombotic complications were due to a restricted excursion of the posterior occluder and resultant stagnation of blood flow[2,3]. This phenomenon, coined as the "lazy" leaflet[1], was found to be avoided with anti-anatomical implantation[1]. This historical observation shaped the standard implantation technique, but practice variation in leaflet orientation persists. Some new-generation MMVs, such as the On-X valve (On-X Life Technologies, Austin, Texas), benefit from a rotatable cuff design, but it is unclear if they are susceptible to asymmetric occluder mobility in the anatomical plane. Valve manufacturers typically endorse anti-anatomical implantation, although it is not formulated as a strong recommendation.

## Description

The patient was a 40-year-old female with rheumatic mitral valve disease and longstanding severe mitral stenosis. She reported significant fatigue and NYHA class II dyspnea. She had undergone successful percutaneous balloon commissuroplasty four years prior to this presentation. Routine serial transthoracic echocardiograms (TTEs) indicated progression of her disease. She had no other significant medical history. Preoperative coronary angiography revealed normal coronary arteries. The patient was scheduled for an outpatient mitral valve replacement via midline sternotomy.

During the operation, the mitral valve was exposed through the interatrial groove. The anterior leaflet was resected and annular calcifications were debrided. The posterior leaflet was tacked to the posterior annulus to maintain annulopapillary muscle continuity. The annulus was sized for a 25/33 mm On-X MMV. Interrupted 2-0 pledgeted sutures were used to sew the ring and after tying all the sutures, the valve appeared to be well-seated. With the prosthesis positioned in the anti-anatomical orientation, gentle probing of the occluders revealed restricted opening. Their excursion appeared to be limited by remnants of native tissue protruding below the level of the posterior annulus. A decision was made to rotate the valve within its sewing ring into an anatomic orientation. Both testing with the leaflet probe and initial transesophageal echocardiogram (TEE) images obtained while weaning from cardiopulmonary bypass (CBP) showed that the MMV was closing and opening well. However, a repeat TEE done at the time of chest closure suggested that while the anterior leaflet continued to move normally, the motion of the posterior leaflet was now restricted, causing an incomplete closure (Fig.1; Supplementary Video 1). The mean transvalvular pressure gradient was still 2 mmHg and there was no regurgitant flow. At that point, the patient was already decannulated. Therefore, we elected to validate our suspicion using cinefluoroscopy. Findings on cinefluoroscopy confirmed limited excursion of the posterior leaflet (Fig.2; Supplementary Video 2) and the decision was made to reinstitute CPB for valve repositioning.

On surgical re-inspection, the infra-annular tissue previously protruding was no longer visible. It is likely that it became tucked under the housing of the prosthesis with repeated ventricular filling and expansion. This allowed us to rotate the prosthesis back to an anti-anatomical orientation. Intraoperative TEE was reassuring and showed normal movement of both occluders. The patient was discharged from hospital after seven days. At the 3-month follow-up, she had made a good recovery and an outpatient TTE showed normal MMV function with low gradients.

## Comment

This case illustrates that the phenomenon of the "lazy" posterior leaflet, originally described in the 1980s, still occurs with new-generation MMVs, revealing the importance of maintaining anti-anatomical orientation. One of the characteristics of the On-X valves is the ability to rotate the sewing ring *in situ* during

implantation. While this feature can be used more arbitrarily in the aortic position, it creates the risk of overlooking careful anti-anatomical orientation in the mitral position.

Two observations suggest that the phenomenon of the "lazy" leaflet is intrinsically related to the heterogeneous distribution of the blood flow dynamics in the left ventricular cavity. First, this phenomenon typically involves the posterior leaflet[1]. Second, as seen in our case, it can occur with newer MMV models, despite their improved physical profiles and features. Under physiological conditions, the diastolic flow acquires a laminar pattern and enters the left ventricle mostly through the posterior portion of the mitral inflow tract[4]. However, in systole, the twisting motion of the contracting heart produces a spiral ejection flow that travels preferentially in the anterior area, corresponding to the anterior leaflet[4]. This, perhaps, underlines one of the roles of the asymmetrical structure of the native mitral valve, which is lost with the symmetrical design of bileaflet MMVs. Furthermore, in our patient, the restricted excursion of the posterior leaflet only became apparent later, probably from the changes of the flow states after weaning from CPB. This observation is in keeping with prior studies that reported further exacerbation of the posterior leaflet restriction in low cardiac output states[2].

Mitral valve replacement comes with several technical challenges. The main one centers on finding the right balance between preservation and debridement. Maintaining the subvalvular apparatus helps retain left ventricular geometry, but leaving excess native tissue risks inadequate fitting of the prosthesis into the annulus and leaflet immobilization. It should also be kept in mind that any prosthetic valve orientation comes with inherent risks of impingement. Because of the geometry of the left ventricle, the closest structure to the valve annulus is usually the posterior left ventricular wall. In bileaflet MMVs, since the leaflets arc into the ventricle, their excursion becomes limited at different points of the arc depending on the valve orientation. In the anatomic orientation, the greatest risk for interference is at the leading edge of the leaflet when it is nearly closed[5]. With the valve oriented in anti-anatomical orientation, the interference occurs with the leaflet fully open[5].

This case also highlights how careful evaluation of leaflet mobility is key to identify the presence of prosthetic dysfunction. Repeated careful TEE examinations, effective team communication and interdisciplinary collaboration are all essential components of the safety culture in cardiac surgery.

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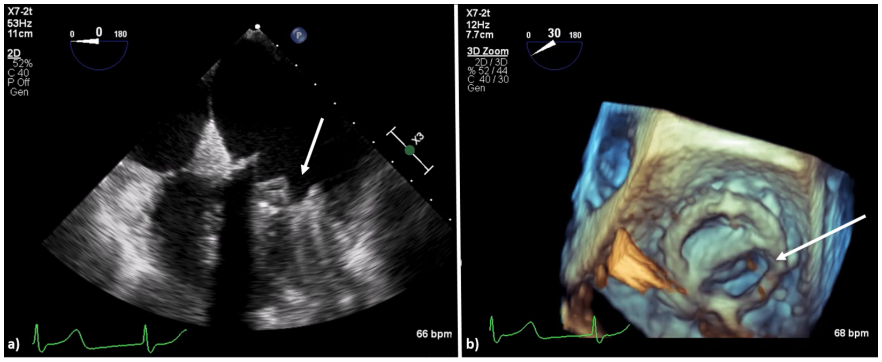
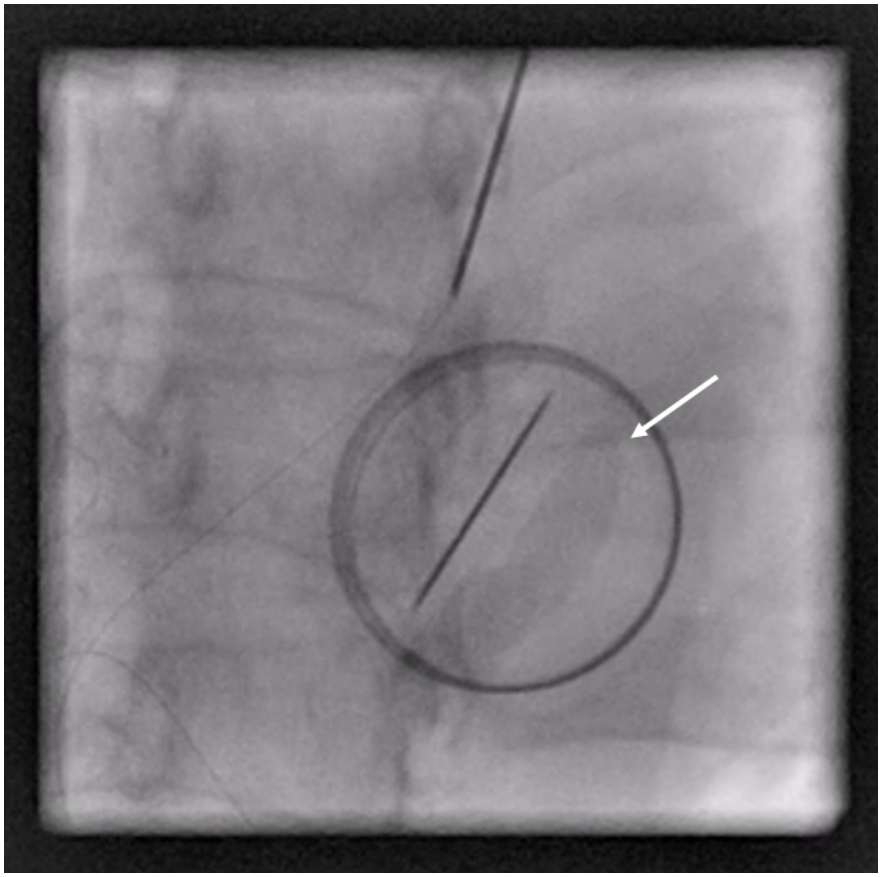
**Figure 1.** Intraoperative transesophageal echocardiogram in 2D(a) and 3D(b) views showing the mechanical mitral valve oriented anatomically, with restricted motion of the posterior leaflet (white arrows).

**Figure 2.** Fluoroscopic left anterior oblique 30° projection of the mechanical mitral valve oriented anatomically showing the posterior leaflet that is opening partially (white arrow).

**Supplementary Video 1.** Intraoperative transesophageal echocardiogram in 2D(a) and 3D(b) views showing the mechanical mitral valve oriented anatomically, with restricted motion of the posterior leaflet.

**Supplementary Video 2.** Fluoroscopic left anterior oblique 30° projection of the mechanical mitral valve oriented anatomically showing the posterior leaflet that is opening partially.



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