

**Title:** A day late and a dollar short

**Running Head:** A day late and a dollar short

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While improvements in cardioplegia solutions have allowed complex surgeries to be performed on the heart, surgeons have also identified clinical situations where a non-arrested heart has shown better outcomes. For example porcelain aorta, low left ventricular function, ischemic cardiomyopathy, reoperative surgery have all been dealt with successfully using a beating heart or fibrillation as a

myocardial protection strategy. Romano (1) reported on 450 patients undergoing redo mitral valve surgery between 1996 and 2011 via right thoracotomy and, either fibrillation (134) or beating heart (316) strategy. The mortality, length of stay, stroke or significant hemorrhage rates were similar between the two groups. However, beating heart patients had fewer transfusions and shorter duration of postoperative intubation. The benefits of a non-arrested heart approach for mitral valve surgery have been elucidated in many other studies using either a conventional sternotomy or via a minimally invasive right thoracotomy approach (2-4). Pasic et al (2) have reported success in 120 consecutive high risk patients 'not suitable' for conventional surgery, who underwent beating heart mitral valve surgery via right anterior thoracotomy (n=42) or median sternotomy (n=78). More than half of these were re-operative procedures. The reasons for being considered 'not suitable' for conventional arrested heart surgery was porcelain aorta, ischemic cardiomyopathy, respiratory failure requiring mechanical ventilation, renal failure requiring dialysis and cardiogenic shock requiring pressors or mechanical support.

With increased acceptance of robotic assistance in cardiac surgery, it was only time before non-arrested heart surgery would find its use in this technique also. In this issue of JCS, Gullu et al, (5) report on 25 patients who underwent predominantly mitral valve and/or tricuspid valve surgery without cardioplegia. The indications for this approach was porcelain aorta or previous surgery making for a difficult and dangerous mediastinal dissection. Patients who underwent right heart procedures were operated on a beating heart, but mitral valve surgeries were performed on fibrillating heart. Mean Euroscore was  $18.5 \pm 22.3$ . One patient suffered a stroke with full recovery within 3 months and two patients with Euroscore of 78.2 and 81.9 respectively, died for an 8% mortality for the whole group.

The biggest limitation of this study is a small heterogeneous patient population with varying severity of illness. Even though the mortality of 8% is high, with better case selection mortality can be brought down to acceptable levels. Similarly, 1 patient with stroke makes it higher than expected (4%), but that again is the problem with a small 'n'. Therefore, higher mortality or stroke risk is not a matter of real concern when analyzing this paper. This report should be taken as an exploration by a group that is experienced in robotic assisted cardiac surgery and is willing to push the envelope. They should be commended for that. Like any other new technique, patient selection is the key. And a few words of caution for those who are thinking of adding this technique to their armamentarium.

First, the entry into the chest can itself be quite difficult and needs attention during preoperative planning. Patients may have significant adhesions in the right chest from prior surgery and lysing those adhesions between the lung and chest wall can sometimes be difficult. Single lung ventilation through the left side is a must for this reason, and the incision may need to be extended in some cases.

Secondly, adhesions between the pericardium and right atrium can be very dense and difficult to take down. The choice is between lysing those adhesions off pump to reduce the pump time vs reducing total operative time and lysing them on a decompressed heart on pump. One has to weigh the benefits of those two approaches. Lysing those adhesions with robotic assistance is tricky since there is no haptic feedback and injury to right atrium is more likely. A minimally invasive long-shafted instrument may be safer than a robotic one.

Choice of beating heart vs fibrillation for myocardial protection is very important. Overall, the two techniques seem to have similar outcomes (1-3), but there are technical differences. Moderate hypothermia (26°C) and relatively higher perfusion pressures (preferably 70 mm Hg) are needed for

adequate myocardial protection during fibrillation, but not for beating heart surgery. Placing a pacing wire on the inferior surface of the right ventricle requires extra dissection and can sometimes be difficult from the right mini thoracotomy incision. This dissection can be particularly treacherous with robotic instrumentation because of lack of haptic feedback. Moreover, it may not always be possible to find an appropriate spot on the ventricle for the pacing wires to capture. The only solution in that case is to cool down, until hypothermia itself induces fibrillation. Another benefit of beating heart tricuspid valve surgery, is that it can identify an annular stitch that would cause AV nodal block and hence heart block may be avoided.

However, there is a good reason the authors chose not to perform beating heart surgery with the robot. With the lack of tactile feedback, motion of the heart may lead damage to the structures during different maneuvers, for example, while putting a needle through the annulus during annuloplasty. A fibrillating heart is almost motionless and more amenable to safe robotic instrumentation.

Finally, the issue of aortic insufficiency and how much can be tolerated during this approach. Most authors exclude moderate or greater degree of insufficiency for this approach. However, even mild aortic insufficiency can make a complex sub-annular repair, such as neo-chordal construction, difficult. A relatively simple annuloplasty may be safely performed with mild aortic insufficiency but caution is recommended for surgeons who are starting their experience with beating heart minimally invasive mitral valve surgery to avoid even mild aortic insufficiency.

In conclusion, it is encouraging to see surgeons beginning to expand their horizons and using technology safely to reduce the trauma related to heart surgery. However, with more advancement in percutaneous mitral repair and replacement therapy, this window of opportunity for surgeons without catheter skills, to treat mitral valve disease may be closing soon. We surgeons may be a day late and dollar short!

## References

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