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Seven Habits of Highly Effective Endoscopic Mitral Surgeons

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The idea of moving from sternotomy to an endoscopic approach for mitral surgery was first put forward in the mid-1990s by the Stanford group.[1] The adoption of this idea has been slow and presently the majority of mitral valve surgery in most countries is still undertaken via sternotomy. Over the past 2 decades there have been many individual surgeons and centers that have been successful in making the transition from sternotomy to an endoscopic approach. At the same time, there has been a larger group that has resisted this change and specific patient-related events have disinclined them further to this approach.

We, as editors, wanted to capture the fundamental issues that lead to some programs being successful and hoped that we could try and identify some features that unify the surgeons who manage to make the paradigm shift in a safe manner.

The late Steven Covey wrote a very successful book on the "Seven habits of highly effective people." This book is a very good read in itself and many cardiac surgeons have already benefitted from understanding the basic tenets of the book that has sold in excess of 25 million copies to date. We unashamedly borrow Covey's title to make an effort to distil 7 specific aspects that need addressing when a surgeon is planning to make the shift away from sternotomy. We do not believe that "rules" apply in surgery, as each surgeon and their team are likely to achieve good outcomes in slightly different ways. We do, however, think these "habits" are likely to help more surgeons to achieve a safe transition to endoscopic surgery for mitral valve disease.

1. Plan Each Step (Be Proactive)

The move from sternotomy to an alternative approach is a significant move not only for the surgeon, but the whole team. This involves meticulous planning to create a successful transition. The first step is for the surgeon to understand the reasons for the change. It may vary in different settings and different countries, but the surgeon has to come to terms with the final goal. At this stage visiting an established center and talking with an experienced surgeon are crucial. This "vision" then needs to be communicated to the team at home, which includes the hospital managers, colleague surgeons and the wider group. The idea of a win–win situation needs to be communicated. With a successful endoscopic surgery program, the number of cases will increase in a department and all parties will be busier in the long term. The initial increase in costs and time per case needs to be factored in and, during this period, support of the surgeon and program are crucial. It is very important to start the program with a specific team as individual learning and team learning are accelerated when the team is stable for a period of time. The team should include specific anesthetic, scrub, and perfusion staff as each person can play a part in the success or failure of the program. The successful impact of this team approach was well documented in an excellent paper on the topic some time ago.[2]

Once a surgeon has secured institutional support, he or she has to decide how they would like to pick the first cohort of patients for this move. It is best to start with patients of a normal body mass index as dealing with excess soft tissue in the early phase is an additional and unnecessary challenge. With increasing experience, obese patients who are likely to benefit more from the endoscopic approach can also be offered surgery, but we would not recommend you tackle these cases early in your learning curve.

When making small incisions, imaging the patient is very important to avoid unexpected anatomy that leads to poor outcomes. Most successful units use either preoperative computed tomographic (CT) scans or magnetic resonance angiograms or Hybrid lab facilities to have a clear understanding of both thoracic and vascular anatomy before selecting patients for an endoscopic approach. We are aware of aortic coarctation, iliac artery interruption, azygous continuation of the inferior vena cava, and patent ductus arteriosus among other things incidentally identified on CT scans that can appropriately lead to alternative surgical strategies. Despite the small delay that extra imaging adds to the patient pathway, to create a large program with a low mortality and low conversion rate, preoperative

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imaging is crucial to the success of most centers and should be increasingly considered a standard of care.

2. Decide on a Cannulation Technique (Begin With the End in Mind)

A very important aspect of endoscopic surgery is identifying alternative cannulation options both for arterial and venous access. Once preoperative imaging is complete, a large proportion of patients will be suitable for a femoral artery cannulation. Previous studies have raised concerns regarding peripheral cannulation and rightly so.[3] Peripheral cannulation has to be combined with both preoperative imaging and intraoperative visualization of guide wires with transesophageal echocardiography (TEE) during cannulation to make this a safe strategy. There will be a group of patients who are not suited to femoral artery cannulation, as identified on preoperative imaging. These patients could be considered for either axillary cannulationor carotid cannulation as described by appropriately experienced aortic surgeons.[4] In our experience, it is a very small group that will need central aortic cannulation but this also can be achieved if required.[5] Some patients may have venous anatomical abnormalities that preclude femoral venous cannulation. Central venous cannulation is possible in selected cases but should be restricted to experienced centers. In our experience, most patients with a normal weight (<80 kg) can have a single femoral venous cannula placed with the tip in the superior vena cava to achieve adequate drainage of the patient. We would recommend an internal jugular cannula routinely in the early part of the learning curve and subsequently in larger patients and those needing right heart procedures.

We cannot stress enough, the importance of planning peripheral cannulation safely in each patient and this step can be the undoing of many surgeons in the early part of the learning curve. Once peripheral cannulation is mastered, its benefits extend to all aspects of cardiac surgery and make a lot of complex cardiac surgery safer. Good peripheral cannulation reduces the stress at the end of the procedure and reduces the potential for bleeding from aortic suture sites.

3. Pick Your Myocardial Protection Strategy (Put First Things First)

The key aspect for the explosion of cardiac surgery across the world has been the introduction of cardiopulmonary bypass and of safe techniques in myocardial protection. The safety of myocardial protection techniques has improved to such an extent, that today it has proved extremely difficult to prove the advantage of off-pump surgery over on-pump arrested heart techniques.[6] This should not be compromised in any way when surgeons make the move to an endoscopic approach. To surgeons starting off, there are 3 clear alternatives to look at. The first and most popular is the use of an external clamp on the ascending aorta. This is intuitively the easier option for most surgeons who are used to placing clamps on the ascending aorta through a sternotomy approach. This has to be combined with a cardioplegia cannula in the ascending aorta to deliver antegrade cardioplegia. The cardioplegia chosen should be the one best suited to the department and the surgeon. There are excellent case series with the use of both crystalloid and blood plegia and the principles of cardioplegia delivery should not be compromised. We have included a video of the application of an external clamp on the aorta performed by one of the authors (Supplemental Video 1).

A less popular but equally effective option is one of an endovascular clamp. This does involve the insertion of a larger femoral cannula to reduce the flow pressure in the peripheral vessels due to space occupied by the catheter within the cannula. This technique received a bad reputation in the initial years due to incidents of retrograde aortic dissection. This was noted to be strongly associated with high line pressures and introducing a second inflow line in the contralateral femoral artery has virtually eliminated the risk of retrograde dissections.[7] A guide for perfusionists is not to exceed 300 mmHg line pressure during cardiopulmonary bypass. The endoclamp also requires excellent TOE guidance and awareness of migration by monitoring both arterial pressures in both radial arteries, which are some of the factors that make this less popular. Another video shows an endoclamp being inflated with TOE monitoring (Supplemental Video 2). As it is a single-use device, there is also a financial impact of using this approach.

A further alternative that is predominantly used in the redo setting, but also by some groups in primary cases,[8] is where the heart is allowed to fibrillate or beat on cardiopulmonary bypass and the procedure is done with coronary perfusion. This technique has previously been proven safeeven through a thoracotomy approach[9] and is increasingly a popular alternative for endoscopic surgeons. An extra pump sucker is required to deal with blood that trickles back into the left ventricle from the thebesian veins and additional time must be allowed for deairing the left ventricle before allowing it to eject back into the circulation.

4. Choose an Endoscope (Think Win–Win)

Many surgeons start to move away from a full sternotomy by initially offering a hemisternotomy or a right minithoracotomy. This is the first step out of the comfort zone that we have been used to and is a necessary step toward change. We encourage these surgeons to take the next step and introduce an endoscope into the field not just to better illuminate the area of work, but to add magnification and better visual definition. With increasing experience, the surgeon will move from looking through the small incision to the large screen with superior clarity and detail and this is when the real advantage of endoscopic cardiac surgery comes into its own. With the endoscope, the utility incision does not need to match the surgeon's interpupillary distance to allow binocular vision but can become smaller as the only limitation to the size is the degrees of motion required for the procedure. The teams that have moved to a totally endoscopic procedure see

Table 1. Pros and Cons of Endoscopy Choice.

	2D HD endoscope	3D endoscope	Robotic endoscope
Cost	High (x1)	Higher (x2)	Highest (X10)
Size of ports	5 mm	10 mm	12 mm
Depth perception	Poor	Excellent	Excellent
Visual comfort	Good	Better	Best
Surgeon tiredness	High	Low	Lowest
Manual dexterity aid	Reasonable	Better	Best
Learning curve	Hard	Easy	Hardest
Assistant view	2D	3D	2D

2D, 2-dimensional; 3D, 3-dimensional; HD, high definition.

benefits in blood loss, length of stay, and recovery times compared to sternotomy.[10]

The type of endoscope used is of importance. Some centers produce excellent results with a 2-dimensional (2D) endoscope but this requires more mental energy and the learning curve can be variable dependent on the individual involved.

Many surgeons including the 2 authors have found the use of 3D endoscopy very helpful and there is evidence from other specialties that this is associated with a shorter learning curve and better depth perception.[11] At present, all 3D endoscopes require a 10 mm port against a 5 mm port for a high-definition 2D camera. We feel the extra 5 mm is a price worth paying but this needs to be evaluated by each surgeon to compare the pros against the cons (Table 1). The surgeon needs to be comfortable working off a large screen and moving from surgical loupes to wearing different 3D glasses. (Figs. 1 and 2).

Robotic surgery also provides the operating surgeon at the console with high-fidelity magnified and motion-stabilized 3D vision but does leave the patient-side surgeon with 2D vision. The major advantage of robotic surgery is conferred by the articulated arms, which aid complex intrathoracic motion. Some surgeons may find this helpful, and if so, they will again need to carefully consider how it is implemented and how the costs will be managed in their own institution. At present, there are no randomized controlled trials or propensity-matched evidence showing an advantage of a robotic strategy over a minimally invasive one.[12]

The endoscope has revived many surgical specialties. Urology and orthopedics have led the way and, lately, abdominal and thoracic surgery have moved to a predominantly endoscopic approach. This has had several advantages. First, it has led to lower morbidity for patients and this, in turn, has permitted more patients to be considered suitable for a procedure. Secondly, it

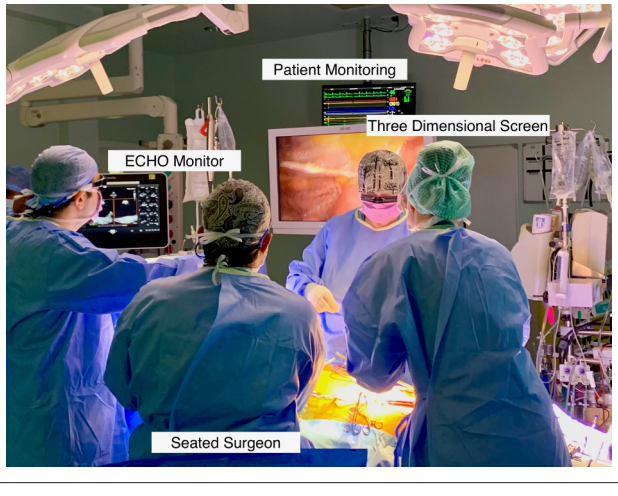

Fig. 1. Operative room setup.

Fig. 2. Surgeon and assistant using 3-dimensional eyewear during surgery.

helps training junior surgeons as they see and learn more from looking at a magnified image on a large screen than the occasional view over someone's shoulder. This attracts a better and more motivated trainee to the specialty. Finally, this has to be seen as a win–win for a department as the more cases that are referred the busier everybody becomes. In both our institutions, our sternotomy surgeon colleagues are doing more operations since we embarked on an endoscopic program as there will always be a group of patients that need a sternotomy approach. The departments benefit from the more motivated junior partners that this strategy attracts, and we have also found a better relationship with our industry partners to be an added bonus.

5. Master Mitral Valve Repair Techniques (Seek First to Understand, Then to Be Understood)

Mitral valve repair is complicated and all surgeons who are involved in this subspecialty interest are on a learning curve, all of the time. The first and foremost principle should be to do the best mitral repair irrespective of the incision. The easiest cases to deal with, through an endoscope, are mitral valves with pure annular dilatation. Leaflets that need a limited triangular resection are likely to be cases that are easy to deal with in the initial part of the learning curve. With increasing experience, a surgeon can move to working on the subannular plane as judging the length of artificial chords can be tricky early in the learning curve.

There is a real need for technology to make this aspect easier. Currently the availability of premeasured chords helps some surgeons deal with complex pathology and achieve excellent results with an endoscopic approach.[13] Centers also achieve similar results with partial bands and complete rings and both options can be used through an endoscopic approach with excellent long-term results.[14] We would recommend surgeons to use the techniques that they are most familiar with and not compromise on the quality of mitral repair.

Despite the best intentions of surgeons, mitral valve repairs do fail sometimes. There is so far, no clear data to suggest that mitral valves repaired through a sternotomy are less likely to fail than those done endoscopically. A randomized trial may provide some light on the subject in time. In the meantime, we believe that patients who have had a sternotomy previously can have an endoscopic approach and those who have had a failed endoscopic approach can have a low-risk sternotomy approach on the second sitting if required. Once again, a more collaborative attitude between these 2 approaches is a better way for the specialty to progress.

In due time we are likely to understand that we need to plan a sternotomy approach for certain pathology and an endoscopic approach for others. With increasing experience and better technology this boundary will continue to shift in each institution over time.

6. Be Aware of Postoperative Pitfalls (Synergize)

Cardiac surgery is a pleasure to perform, although the joy is sometimes tempered by the incidence of unpredictable complications. Over the years we have come to accept the many shortcomings of a sternotomy approach as a price to pay for our way into the chest. Moving to an endoscopic approach brings a new set of complications that surgeons need to be aware of. With experience and careful attention to detail these compilations can be reduced to very low levels.

One common problem after endoscopic surgery is the groin hematoma or seroma related to femoral vessel dissection. Moving the skin incision to above the groin crease and reducing the dissection to the front wall of the vessels can eliminate this frustrating complication. Using newer technology that allows percutaneous cannulation and dressings that have in-built suction may be an alternative to reduce these in the future for high-risk patients.

Phrenic nerve palsy is rare, but can have devastating sequelae, leaving asymptomatic patients with new breathlessness. Beware of the phrenic nerve when opening the pericardium, as traction too close to the phrenic nerve can lead to a neuropraxia that can take up to 6 months to recover from. Diathermy close to the nerve can lead to irreversible damage and should be avoided.

There have been anecdotal reports of poor myocardial protection and this needs to be looked at in context of the experience of many centers where there have not been increased reported use of intra-aortic balloon pump or assist devices.[10,12] If this problem is noted by a surgeon or at a center, a root cause analysis may throw light on the specific aspect and hopefully a period of supervision from another center or surgeon will help them overcome this issue.

A cerebrovascular event is another feared complication of an endoscopic approach and previous reports have suggested a higher incidence of this compared to sternotomy surgery.[3] We have not found this to be a concern if patients are selected for this approach with preoperative imaging.[10,14] There have been reports of unilateral pulmonary edema early in some case series though the cause is still not yet fully understood.

Cardiac tamponade is less likely after endoscopic surgery. In the very occasional case of bleeding from the atrial suture line, the blood overflows into the right chest due to the open pericardium on the right side. A regular chest X-ray is recommended, and any pleural effusions are best dealt with quickly if noticed.

As a group of surgeons, we need to come together to understand each potential complication and work toward a strategy to avoid them going forward. Some of these complications may need help from industry partners but we need to work together with the overall aim of making this approach both reproducible and safe.

7. Reflect and Learn (Sharpen the Saw)

The most important advantage of an endoscopic approach has to be the ability for surgeons to be able to record the procedure in real time. This can lead to reflective learning by reviewing the video after the procedure. Most endoscopic surgeons spend some time looking back at the operative video and often are able to comment on how they could do the procedure better next time. This cycle leads to constant improvements and in turn leads to better outcomes. There is increasing evidence to support the long-suspected fact that surgical skill affects patient outcomes.[15] With increasing use of endoscopes we will be able to not only learn from our own work but also from each other. Sharing videos between surgeons will become a powerful tool in transferring good practice and a pilot program is already showing benefits in pediatric cardiac surgery training in the USA.[16]

Constant improvement requires a great deal of insight. This is not always available and is often absent in those surgeons who probably would benefit the most. Recording an endoscopic procedure will be a first step in creating a transparent system where surgical skill can be commented upon and improved both during training and subsequently in later years.

Recording devices have greatly helped improve the assessment and behavior of motorists and the police when trialed.[17] It is only a matter of time when it will be expected of surgeons too. Future surgeons are more likely to be judged by the quality of their surgical videos than the number of publications.

A Mindset of Abundance

Taking a further leaf out of Stephen Covey's book, we in cardiac surgery need to embrace endoscopic surgery by changing our mind frame from one of "scarcity" to "abundance." Department leads need to see endoscopic cardiac surgery as a collaborative approach that needs developing within each team. Transcatheter technologies have threatened our specialty for some time but it seems unlikely that they will ever replace the need for cardiac surgery. Increasing number of surgeons and centers are seeing their work reduced as more patients choose a transcatheter approach. We cannot expect patients who are older and more frail than ever before to accept the morbidity associated with a sternotomy in the coming years, especially as we move to treat asymptomatic patients. This editorial captures the expertise of 2 busy endoscopic surgeons who have seen their work grow in the past years. With the increase in global populations and a more aging group of individuals, there is sadly enough disease substrate to keep us all busy at work. We cannot hope to compete against a catheter with a saw. We are more likely to prevail with an endoscope.

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Supplemental Material

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