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Chapter 13

Collaboration between Interventional Cardiologists and Cardiac Surgeons in the Era of Heart Team Approach

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Abstract

Along with the rapid evolution of transcatheter interventions, interventional cardiologists are playing more and more important role in the care of cardiovascular disease. The consequence of rapid change in the landscape has been fostering new and improved relationships between interventional cardiologists and cardiac surgeons and the formulation of Heart Team to facilitate patient management. A hybrid strategy is a combination of tools available only in the catheterization laboratory with those available only in the operative room in order to gain maximum profit from both of them. In the current era, the continuous development in transcatheter procedures along with the adoption of minimally invasive surgical approaches makes hybrid strategy an attractive alternative to conventional surgical or transcatheter techniques for any given set of cardiovascular diseases. In the areas of coronary revascularization, valve repair or replacement, and ablation for atrial fibrillation, hybrid approaches have shown great benefit especially in high-risk cases. With the technological evolutions in the treatment of cardiovascular disease, the Heart Team approach utilizing the expertise of all relevant specialties will be more and more invaluable in facilitating optimal patient selection, procedural planning, complication management, postprocedural care, and patient outcomes.

Keywords: interventional cardiologist, cardiac surgeon, hybrid, heart team

1. Introduction

A hybrid approach combines the treatments traditionally available only in the catheterization laboratory with those traditionally available only in the operative room in order to obtain maximum benefit from both procedures. The continuous evolution of transcatheter technology

along with the adoption of minimally invasive surgical approaches make hybrid procedures an attractive alternative to conventional surgical or interventional techniques for a wide variety of cardiovascular diseases [1–3]. Angelini et al. reported the first case series of hybrid coronary artery revascularization in 1996 [4]. Since then, along with technological advancement, hybrid procedures are currently applied not only for coronary artery disease, but also for valvular heart disease, arrhythmia, congenital heart disease, aortic diseases, and peripheral vascular disease.

As a result of rapid evolution of transcatheter techniques, interventional cardiologists are playing a central role in the management of cardiovascular diseases. For a success of hybrid approach, a formulation of Heart Team combined with good collaboration between interventional cardiologists and cardiac surgeons is encouraged to facilitate patient management. The indications and patient selection for hybrid procedures need to be well discussed in Heart Team.

2. Hybrid coronary revascularization (HCR)

2.1. Rationale of HCR

Despite the increasing use of percutaneous coronary intervention (PCI) for coronary artery disease during the past decade [5], coronary artery bypass grafting (CABG) remains the gold standard for multivessel coronary artery disease or left main disease [6]. A number of major trials such as SYNTAX [7], ASCERT [8], and FREEDOM [9] reported superior long-term survival rates of CABG compared with PCI.

The main factor of the superiority of CABG over PCI is the use of left internal mammary artery (LIMA) to left anterior descending (LAD) artery [10, 11]. The excellent long-term patency of LIMA to LAD graft has been established [12–14], whereas the long-term outcomes of other conduits such as saphenous vein graft and radial artery have been reported to be poorer than those of LIMA. The patency rates of saphenous vein grafts were 71–87% at 1-year after surgery in previous studies [15–17], and up to 50% at 10-years [15–19].

On the other hand, newer generation of drug-eluted stents are associated with fewer restenosis and repeat revascularization compared to conventional bare metal stents [20], and are associated with similar or even better long-term patency rates than saphenous vein grafts [11, 17, 21–23]. Thus, the combination of LIMA-LAD bypass and PCI using new generation of drug-eluting stents to non-LAD lesions takes the advantage of both procedures. The rationale of HCR is to combine the survival benefit and high patency rates of LIMA graft with the lower restenosis rates of new generation drug-eluting stents for non-LAD lesions [11, 24, 25].

2.2. Indications of HCR

HCR is applicable in patients having multivessel coronary artery disease with CABG-suitable LAD disease and PCI-suitable non-LAD disease [1, 11, 26–28]. HCR takes the most advantage in patients with comorbidities such as diabetes mellitus, obesity, chronic kidney disease, chronic occlusive pulmonary disease, and advanced age [11, 28], because these comorbidities are known to increase the risk of conventional CABG.

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On the other hand, there is a couple of situations where HCR is not suitable, such as left subclavian artery stenosis, nonusable LIMA graft due to prior radiation to the left chest, intramyocardial LAD, previous stent to the target lesions, and extensive calcification on LAD [27, 29].

American guidelines for HCR demonstrate that HCR is reasonable in patients with one or more of the following: limitations to traditional CABG, such as heavily calcified proximal aorta or poor target vessels for CABG but amenable to PCI; lack of suitable graft conduits; unfavorable LAD for PCI such as excessive vessel tortuosity or chronic total occlusion with Class IIa recommendation with level of evidence of B. Also, HCR may be reasonable as an alternative to multivessel PCI or CABG in an attempt to improve the overall risk-benefit ratio of the procedures with Class IIb recommendation with level of evidence of C [3].

2.3. Techniques of HCR

Several techniques have been reported for achieving minimally invasive CABG [1]. Thoracoscopic endoscopic CABG; LIMA graft is harvested with the use of thoracoscopy through a port-access approach. The LIMA-to-LAD anastomosis is then performed by hand on the beating heart using specially designed stabilizers and retractors [2]. Robotically assisted CABG; LIMA graft is harvested with an assistance of robot followed by a hand-sewn LIMA-to-LAD anastomosis on the beating heart [3]. Totally endoscopic CABG, LIMA harvest and the anastomosis are performed endoscopically with the robot. The anastomosis can be performed on the beating heart or on cardiopulmonary bypass on an arrested heart.

HCR can be performed either as a one-staged or a two-staged procedure. A two-staged procedure is defined as a PCI and CABG performed separately by hours or days. A one-staged HCR is defined as PCI and CABG performed in a hybrid-operating room in one operative setting. The advantages of one-staged HCR include complete revascularization with minimal patient discomfort, intraoperative confirmation of LIMA-to-LAD anastomosis, and easy conversion to conventional CABG if needed [29]. However, bleeding concerns due to dual antiplatelet therapy and incomplete heparin reversal, as well as acute stent thrombosis possibility are disadvantages of one-staged HCR [11].

In a two-staged approach, there is a concern of adverse coronary events between the procedures because patients are incompletely revascularized. When PCI is preceded, CABG needs to be performed under the effect of dual antiplatelet therapy, which leads to significant bleeding risk. On the other hand, when CABG is preceded, PCI can be performed under the protection of the LIMA-to-LAD graft and the ability to verify the patency of the LIMA-to-LAD graft while avoiding the risk of bleeding due to dual antiplatelet therapy. Therefore, CABG-first strategy for two-staged HCR is preferable.

2.4. Outcomes of HCR

The surgical outcomes of previous studies regarding HCR are summarized in **Table 1**. The 30-day mortality after HCR ranged from 0 to 2.4%. LIMA patency is reported to be over 90%. The event-free survival rate ranged from 83 to 100%, whereas the incidence of major adverse cardiac and cerebrovascular events (MACCEs) ranged from 0 to 12.2%. However, the sample size of each study was relatively small.

Study	Year	Number of pts	Follow-up (months)	30-day mortality (%)	MACCE (%)	Event-free survival (%)
Angelini et al. [4]	1996	6	–	0	–	89
Leacche et al. [25]	2013	80	1	–	2.5	91
Rab et al. [53]	2012	22	38.8 ± 22	0	0	95
Lewis et al. [54]	1999	14	1.44	0	–	93
Isomura et al. [55]	2000	37	24	1.4	–	92
Presbitero et al. [56]	2001	42	18	2.4	12.2	83
Lee et al. [57]	2004	6	12	0	0	–
Repossini et al. [58]	2013	166	64.6 ± 12.0	1.2	12	83 (at 5 years)
Gilard et al. [59]	2007	70	33	1.4	–	97
Kon et al. [60]	2008	15	12	0	–	93
Vassiliades et al. [61]	2006	47	7	0	–	90
Bonatti et al. [62]	2008	5	6	0	–	100

Note: MACCE; major adverse cardiac and cerebrovascular events.

Table 1. Outcomes of hybrid coronary revascularization.

Zhu et al. performed a meta-analysis to compare the short-term outcomes of HCR with those of CABG for multivessel coronary artery disease. They found that HCR was noninferior to CABG in terms of the incidence of death, myocardial infarction, stroke, and renal failure, whereas HCR was associated with less blood transfusion and shorter length of stay in hospital [30]. Halkos et al. compared the outcomes of 147 HCR cases with matched off-pump CABG cases. They reported 5-year survival rate and the incidence of MACCE were similar between HCR and off-pump CABG, whereas the need for repeated revascularization was higher in HCR group [31].

3. Transcatheter treatment for aortic valve disease

For the treatment of severe symptomatic aortic stenosis, surgical aortic valve replacement has been the gold standard. The advent and rapidly widespread adoption of transcatheter aortic valve replacement (TAVR) has now resulted in it becoming the option for patients who would have been considered inoperable or prohibitively high surgical risk [32]. Excellent mid-term

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and long-term outcomes after TAVR have been reported [33, 34], and indications of TAVR are expanding to severe aortic valve regurgitation associated with moderate aortic valve stenosis and valve-in-valve procedures for surgical bioprosthetic valve failure.

TAVR procedures are now shifting to percutaneous approach and even general anesthesia is not mandatory. The percutaneous transfemoral route is the preferred approach in the majority of the cases due to its associated advantages [35]. Although some centers reported that transapical and transfemoral approach resulted in the similar outcomes [36], transapical approach is usually associated with poorer outcomes than transfemoral approach [37]. Interventional cardiologists possess the required skills for transfemoral TAVR including the handling of guidewires, catheters, and image selection. They can even take care of technical complications associated with TAVR, such as coronary obstruction and conduction disturbance by performing PCI or implanting pacemaker. Although interventional cardiologists can take a lead in TAVR procedures, surgeons still play an important role in managing life-threatening complications such as aortic root rupture, cardiac tamponade, and vascular complications. Those complications cannot be managed percutaneously and surgical interventions are the only viable rescue option. Furthermore, surgeons have the skill to ensure procedural success in patients whom transfemoral approach is not applicable. For the success of transapical and transaortic TAVR procedures, surgeons play a crucial role and they should be familiar with individual cases and technical aspects.

Postprocedural care and rehabilitation are undoubtedly important in optimizing functional status and clinical outcomes [38]. Cardiologists can take the leading role in this area by virtue of familiarity with all aspects of general cardiology issues such as heart failure and arrhythmia in the management of these complex patients.

In conclusion, a good collaboration between interventional cardiologists and cardiac surgeons and formulation of a Heart Team is essential for the success of TAVR. The decision making for patients selection and surgical approach, the actual performance of procedure in the operating room, and postoperative care should be performed by a Heart Team approach [39].

4. Transcatheter treatment for mitral valve disease

4.1. Transcatheter mitral valve repair

The prevalence of mitral regurgitation is higher than other valvular heart diseases [40, 41]. Surgical mitral repair remains the gold standard for patients with primary mitral regurgitation. However, there are a growing number of patients with mitral regurgitation underserved by surgical therapy due to prohibitive surgical risks. The recent development of transcatheter mitral valve technique provides an additional therapeutic option for some high-risk and inoperable patients [42, 43]. The optimal way to adjudicate innovative surgical and interventional mitral therapies is through a robust collaboration within a well-functioning Heart Team which includes not only cardiac surgeons and interventional cardiologists but also imaging specialists.

The current leader in the field of transcatheter mitral repair device is the MitraClip (Abbott Vascular, Santa Clara, CA). This device is delivered in an antegrade transseptal approach across the atrial septum from the femoral vein to achieve an edge-to-edge direct leaflet approximation (**Figure 1**). More than 30,000 patients worldwide have been treated with this procedure to date. In the United States, a Society of Thoracic Surgeons (STS)/American College of Cardiology database analysis of the first 564 cases performed through August 2014 showed the average patient age was 83 years, with a median STS predicted risk of mortality for mitral valve repair and replacement of 7.9 and 10.0%, respectively. The majority of the patients had prohibitive surgical risks such as severe frailty, prior cardiac surgery, and end-stage heart failure. The procedural success rate was 91.8% with a 30-day operative mortality of 5.8% [43].

The randomized EVEREST II trial showed that the need for surgery for residual mitral regurgitation was significantly higher in patients who received MitraClip compared with those who underwent surgery at 1 year and 5 years; however, the MitraClip procedure was associated with superior safety and similar improvements in clinical outcomes [44, 45]. Currently, guidelines state that MitraClip can be considered in patients with severe primary mitral regurgitation who meet the echocardiographic criteria of eligibility, and are judged inoperable or at prohibitive surgical risk by a Heart Team [32, 46]. Further studies are needed to apply this technique to intermediate- or low-risk patients.

In conclusion, the MitraClip procedure has proven reasonable safety and efficacy in high-risk patients and is already considered as an established part of the mitral valve program in high-volume centers. A multidisciplinary Heart Team approach will play a crucial role for careful patient selection and clinical application of the transcatheter interventions as a part of a successful and multimodal mitral valve program [47].

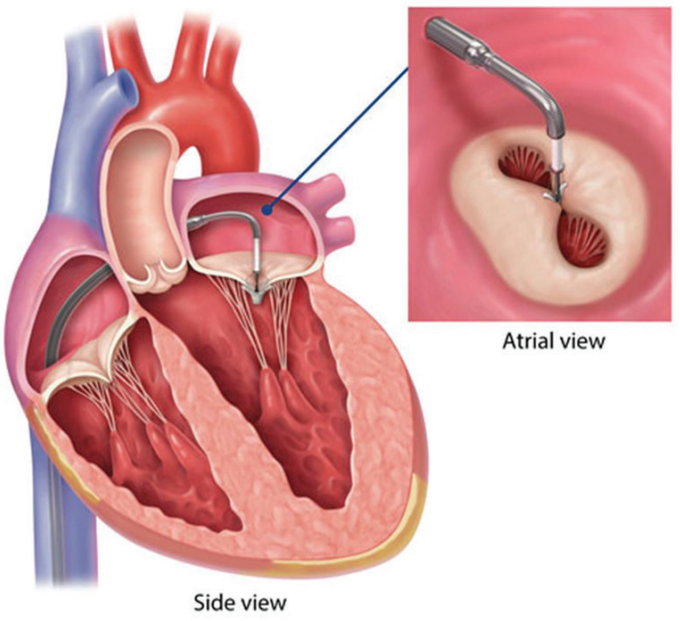

Figure 1. MitraClip (Abbott Vascular, Santa Clara, CA) is a percutaneous mitral valve repair using anterior-posterior edge-to-edge direct leaflet approximation.

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4.2. Transcatheter mitral valve replacement

Unlike transcatheter mitral valve repair, the challenges of deploying and anchoring a functional prosthetic device into the mitral valve annulus amid the intact subvalvular apparatus is more complex. As of January 2016, the total human experience with transcatheter mitral valve replacement implantation surpassed 50 cases, with half of those performed in the United States [43]. The preliminary outcomes have been promising so far.

The Tendyne device (Abbott Vascular, Santa Clara, CA) is a potentially fully retrievable trileaflet porcine pericardial valve with an impermeable nitinol skirt which has a prominent cuff positioned to rest on the intertrigonal aortomitral curtain [48] (**Figure 2**). The Tendyne is an intraannular valve that does not specifically capture the leaflets, and thus the primary clinical target is patients with functional mitral regurgitation. The first US use of Tendyne device was in April 2015. Currently, multiple experienced centers have been chosen for the Food and Drug Administration (FDA) clinical trial for high risk patients inoperable for conventional mitral valve replacement. Several other devices for transcatheter mitral valve replacement are also in the stage of clinical investigation.

Despite continuing innovation, current transcatheter mitral valve replacement delivery systems remain large and the majority require a transapical retrograde approach to the mitral valve. Therefore, the collaboration between interventional cardiologists and surgeons is needed as with the transapical TAVR procedure.

Figure 2. Tendyne (Abbott Vascular, Santa Clara, CA) is a transapically delivered porcine pericardial valve for transcatheter mitral valve replacement.

5. Hybrid approach for atrial fibrillation

Nowadays the majority of ablations for symptomatic atrial fibrillation are catheter-cased. In the United States from 2000 to 2010, over 93,000 catheter ablations were performed for atrial

fibrillation [49]. However, the outcomes of catheter ablation for patients with significant valve disease and long-standing persistent atrial fibrillation remain poor [50]. For patients who have valvular heart disease or patients who are refractory to antiarrhythmic drugs or catheter ablation, surgical ablation called Cox-Maze procedure is recommended [51].

The hybrid approach for atrial fibrillation represents a collaborative between cardiac surgeons and cardiologists utilizing the strengths of both techniques in order to achieve outcomes that maximize the success rates and minimize the procedural complications. There are several potential advantages to a hybrid approach [50]. From a surgical standpoint, direct visualization allows surgeons to perform aggressive ablation at sites which may be challenging for catheter ablation due to risk of injuring esophagus or phrenic nerves, and also allows surgeons to confirm of transmurality of ablation. Moreover, the ability to exclude the left atrial appendage serves to potentially eliminate need for anticoagulation. On the other hand, catheter ablation allows more complex mapping of the left atrium for either complex fractionated atrial electrograms or rotors.

Hybrid procedures incorporate both an epicardial surgical ablation and endocardial catheter ablation [52]. The procedure can be done in either one-staged or two-staged fashion. The outcomes of hybrid approach for atrial fibrillation in previous studies are shown in **Table 2**. While all procedures were done through minimally invasive approach, the approach varied with right,

Study	Year	Number of pts	Follow-up (months)	Mortality (%)	Success rate off AA drugs (%)	Success rate on AA drugs (%)
Mahapatra et al. [63]	2011	15	20.7 ± 4.5	0	86.7	93.3
Krul et al. [64]	2011	31	12	0	86	–
Pison et al. [65]	2012	26	12	0	92	–
Muneretto et al. [66]	2012	36	30	0	77.7	91.6
Gersak et al. [67]	2012	50	24	4	87	–
La Meir et al. [68]	2013	35	12	0	91.4	–
Gehi et al. [69]	2013	101	12	2	60.7	73.3
Bisleri et al. [70]	2013	45	28 ± 1.7	0	88.9	–
Gersak et al. [71]	2014	73	12	0	52	80
Bulava et al. [72]	2015	50	12	0	84	94

Note: AA, antiarrhythmic.

Table 2. Outcomes of hybrid approach for atrial fibrillation.

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and bilateral thoracoscopic approaches as well as subxiphoid and laparoscopic access. Overall, hybrid ablation procedures are associated with low mortality which is up to 4%. High success rates are reported noting sinus rhythm off antiarrhythmic drugs in about 87% of cases and in about 92% when antiarrhythmic drugs are added.

In conclusion, for the success of the hybrid ablation for atrial fibrillation, a creation of a collaborative team between cardiac surgeons and electrophysiologists is crucial. This collaboration will permit important advances in improving the outcomes of procedure especially in challenging patients.

6. Conclusions

Nowadays, the cases of patients who suffer from cardiovascular disease are more and more complex. Along with the technological advancement, patients who used to be thought inoperable can be treated by a new technology with a reasonable risk. Interventional cardiologists tend to be more invasive in their field, whereas cardiac surgeons tend to seek for minimally invasive approach. There are advantages and disadvantages in both surgery and interventions. The rational for hybrid procedures is to achieve the best outcome by combining the strengths of both surgery and interventional procedures. The key point for the success of hybrid procedures is the collaboration between interventional cardiologists and cardiac surgeons. In the current era, patient selection and indications for each procedure must be well discussed in a well-functioning Heart Team.

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