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Multicenter Experience of Prospective Comparative Study between two different Approaches for Isolated Aortic Valve Replacement; Upper Mini-Sternotomy, and Right Anterior Mini-Thoracotomy

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ABSTRACT

Objective(s): Surgical Aortic valve replacement (sAVR) is one of the most common valve surgery associated with excellent Results. SAVR can be performed via a full sternotomy (FS) or a minimal invasive surgical (MIS) approach. Many studies compared outcomes of AVR through upper mini-sternotomy (UMS) versus full sternotomy (FS) and others compared right anterior mini-thoracotomy (RAMT) versus full sternotomy (FS). Our aim was to compare early outcomes of AVR by UMS versus RAMT.

Methods: The prospective, randomized, comparative multicenter study compared surgical and early outcomes of patients who underwent elective isolated SAVR from January 2021 to January 2024. All consecutive patients had aging group 65-75 years old. Patients are divided into two groups; group [RAMT] and group [UMS]. Selection of RAMT groups according to preoperative chest computed tomography (CT). All patients who had severe aortic stenosis [AS] received a bioprosthetic valve suture bioprosthetic, group [S], or sutureless (Perceval) [SURD].

Results: No differences in both groups about age, preoperative risk factors, and postoperative complications. Operative time was significantly shorter for the SURD group, regardless of approach. However, nowadays a core- knot in the suture valve made almost no time difference. UMS group had less postoperative pain than RAMT group, however with using analgesic and pain killer made differences not obvious. RAMT group had more lung atelectasis, pleural effusion, and limited mobility of the right arm in the first few postoperative days. UMS group could be easily converted to FS if needed. The RAMT had more cosmetic and patient satisfaction.

Conclusion: Both approaches are nearly similar in early outcomes and consider the future of total endoscopic and robotic cardiac surgery.

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Introduction

Nowadays, minimally invasive aortic valve replacement (MIS-AVR) for patients fit for surgery replaced full sternotomy (FS) [1]. MIS-AVR had less morbidity and more cosmetic incision when compared with FS. It had two approaches; upper mini-sternotomy (UMS) and right anterior mini-thoracotomy (RAMT) [2].

In addition, using of sutureless and rapid

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deployment Perceval valves (SURD) made MIS-AVR entered competition with transcatheter intervention (TVAI) especially in old age patient fit for surgery [1]. It is an alternative option to sutured AVR in patients presenting with severe aortic stenosis with small annulus [3]. Its use reduces both aortic cross-clamping and cardiopulmonary bypass (CPB) times [1].

MIS-AVR advantages include less surgical trauma, decrease blood loss, decrease needs for transfusion, and reduce stay duration at intensive care unit (ICU), and total hospital stay and rapid recovery. Moreover, it improved cosmetic wound appearance, reduced postoperative pain, and increase patient satisfaction. MIS-AVR disadvantages are; decreasing exposure field, and possibility of conversion to standard sternotomy. More experiences in that field of MIS decrease rate of conversion to FS and provide less aortic cross-clamping and CPB times [3]. MIS-AVR Contraindications are including; presence of chest wall deformities or radiotherapy, previous right thoracic surgery, severely calcified ascending aorta, reoperation aortic surgery, previous coronary bypass surgery (CABG) [4]. Exclusion criteria for Perceval implantation through a RAMT approach were acute endocarditis, irregular aortic annulus, bicuspid aortic valve (BAV), or failure of peripheral percutaneous cannulation [5].

Materials and Methods

We performed 5000 cases of AVR in our centers either by TAVI or SAVR through different approaches; FS, UMS, and RAMT. Our research is prospective, randomized, comparative multicenter study compared between UMS and RAMT approaches. The study included 600 patients who underwent MIS for elective isolated AVR from January 2021 to January 2024. Patients are divided into two groups; group RAMT and group UMS. All patients had aging group 65-75 years old. All patients who had severe aortic stenosis (AS) received a bioprosthetic valve. All patients were receiving suture bioprosthetic valve, group [S], or sutureless Perceval valve [SURD] group. We are followed them in-hospital and short term duration for morbidity and mortality.

Preoperative workup performed included full history and examination, full labs, electrocardiography (ECG), chest x-ray (CXR), transthoracic echocardiography (TTE), non-contrast chest computed tomography (CT). Computed tomography angiography (CTA) is an alternative choice instead of chest CT and coronary angiography.

RAMT requires a suitable anatomy, ascending aorta should be at least 50% of the width of the aorta to right of sternal margin at the level of bifurcation pulmonary trunk, and the depth of the aortic root should not be more than 10 cm from sternum. A 5cm incision was performed through in 2nd intercostal space using a soft tissue retractor (Alexis) for exposure (Figure 1).

UMS involves splitting the upper half with intact the caudal part of sternum that is allowing central cannulation while avoid long time sternal precaution of FS. It is the J-shaped, a 5-7cm skin incision and extending to the 4th right intercostal space.

SAVR steps are very similar to those performed through FS except peripheral aortic and venous cannulations were performed through *femo-femoral bypass*. However, central aortic cannulation was performed in almost of UMS cases. Transesophageal echocardiographic (TEE) was guiding proper position of venous cannula. Initiation of vacuum-assisted CPB was facilitating venous return. The ascending aorta was clamped. Left ventricular vent and antegrade cardioplegia solution was delivered into the aortic root and\

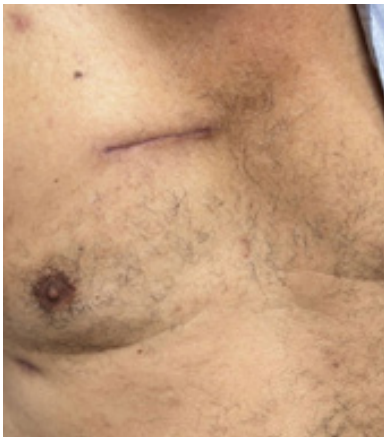

Figure 1. Right Anterior Mini Thoracotomy wound

or selectively into the coronary ostia using cold blood cardioplegia or Custodial. We usually used carbon dioxide (*CO2*) during valve surgery to flood the surgical helping in de-airing. Aortotomy done and aortic valve leaflets were excised. The annulus decalcified by *Ronguer* and washed with protection of coronary ostia. A standard implantation sutureless prosthesis technique was implemented or suture bioprosthetic valves. The aortotomy was closed with a continuous 4-0 polypropylene suture and the patient weaned from CPB. TEE was showed well function of bioprosthetic valve without gradient, and guiding us during de-airing after weaning from CPB (Figure 2, 3).

Perceval aortic valve is a biological prosthesis composed of bovine pericardium mounted. It collapsed through a dedicated device and positioned by means of a specific delivery system, Figure (3A, B). The delivery system loaded with the collapsed stent-mounted valve, is guided to its correct position by advancing it over the three guiding sutures (4/0 polypropylene), positioned at the nadir level of each resected cusp. Once the delivery system is in position, the prosthesis is deployed, the guiding sutures are removed and the correct valve position is confirmed. At this point post-dilatation modeling is performed with a balloon for 30 seconds at 4 atmospheric pressure, while the valve is flushed with warm saline at 37 °C to optimize final sealing (Figure 4, 5).

We routinely prescribed warfarin for 3 months duration after Perceval implantation and suture biological valve reaching an INR ranging (2-3). After 3 months, unless another indication for anticoagulation exists, warfarin is replaced by 81 mg of aspirin daily. We followed data preoperative risk factors [gender, age range between 65-75 years old, body mass index *BMI*, hypertension,

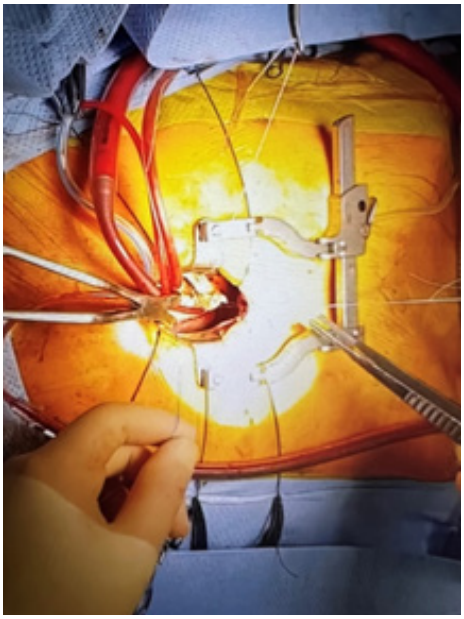

Figure 2. AVR through upper mini sternotomy

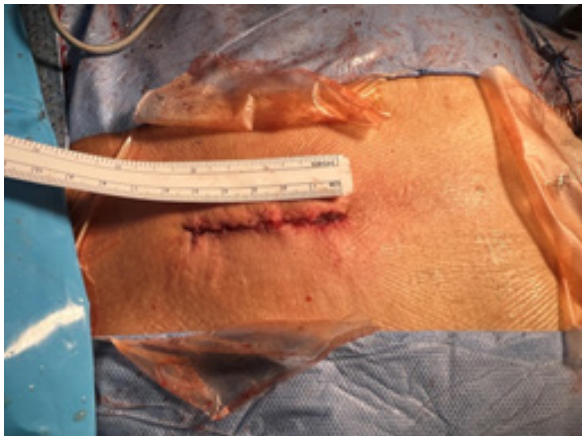

Figure 3. Upper mini sternotomy wound

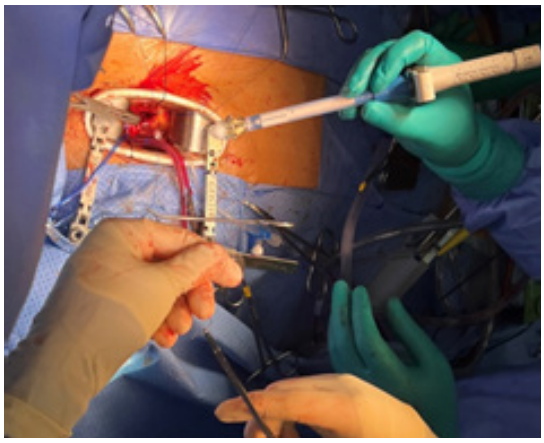

Figure 4. Insertion of Perceval through Right Anterior Mini Thoracotomy

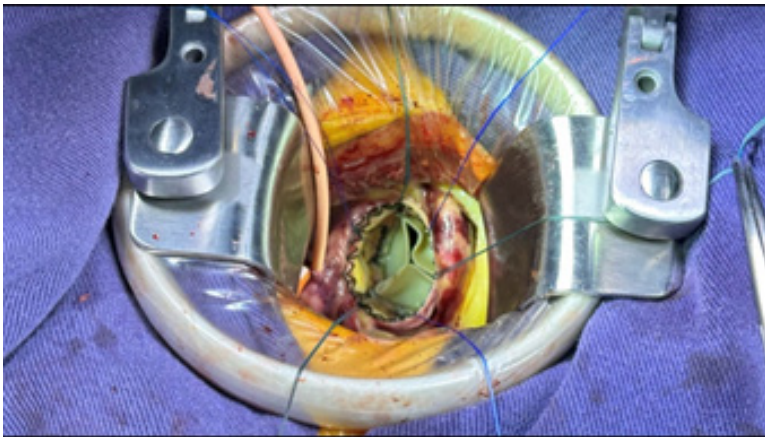

Figure 5. Perceval after insertion

diabetes mellitus, hypothyroidism, previous stroke or seizures, dyslipidemia, smoking, chronic obstructive pulmonary disease *COPD*, renal impairment] intra-operative data [aortic cross clamp ACC and CPB time, inotropic support, surgical approach, blood loss] and also postoperative data [duration of ventilation, early mobilization, ICU and total hospital stay, inotropic support, pain score, blood transfusion requirement, any in hospital morbidity or mortality, surgical wound infection (SSI), appearance and patient satisfaction, return to daily activity].

Results

Our centers performed about 5000 cases of AVR in that age (65-75) years old; TAVI (N = 2460) cases, and SAVR (N=2540) cases. Isolated AVR (N=1350) cases performed by different surgical approaches either FS (N= 180), UMS (N=820), and RAMT (N=350). From January 2021 to January 2024, we divided MIS-AVR into two groups; RAMT group and UMS group. All patients received a bioprosthetic valve. All patients were receiving either suture surgical bioprosthetic aortic valve, group [S] (N= 1595), or sutureless *(Perceval)* [SURD] (N= 945). SURD were (N=837) in UMS, and (N=108) in RAMT. Preoperative risk factors were equal in both groups without big difference. However, the RAMT group was more common in females (65%) especially according to patient preferences. No cases needed conversion to FS. Almost of cases received Coumadin for 3 months postoperative and aspirin for long-life. This study highlights important differences in short-term outcomes between UMS and RAMT as approaches for SAVR (Table 1).

There was no difference in operative mortality between UMS and RAMT *(P = 0.6)*. The rate of conversion to FS was zero in both groups. Complications during hospital stay like; stroke, atrial fibrillation, and surgical site infection were similar between the two groups. The length of hospital stay was shorter for RAMT *(P=0.01)* and the length of postoperative ventilation was borderline significant in favor of RAMT *(P=0.09)*. CPB and ACC were significantly shorter in RAMT group than in UMS group (p=0.001 and p<0.001,

Table 1. Patient characteristics

COMPARISON	RAMT	UMS	P-VALUE
Female gender	93%	65%	
BMI	28.5±5	29±6.3	0.399
Hypertension	79.9	78.3	
Dyslipidemia	63.9	67.2	0.387
Diabetes mellitus	18.1	21.2	0.387
COPD	7 9	0.2	
Atrial Fibrillation	5.9	8.7	0.16
Coronary Artery Diseases	18.4	25.3	0.031
NYHA class III\IV	79.6	71.5	0.016
Pulmonary hypertension	2.5	35.1	0.067

respectively). Time to first mobilization and hospital stay were significantly shorter in RAMT group than in UMS group (p=0.005, p=0.001, respectively). A significantly lower incidence of revision surgery was noted in RAMT group than in UMS group (p=0.04). No significant differences in mortality were noted (Table 2).

A predominance of female gender has been observed in both groups with more in RAMT. The ACC and CPB times were significantly lower in UMS compared with RAMT approach. RAMT had significantly shorter lengths of wounds. UMS had significantly lower postoperative pain scores either at ICU, one week, and one month postoperative compared with RAMT. In-hospital outcomes of stroke, atrial fibrillation (Afib), heart block with permanent pace maker insertion, SSI, and operative mortality were similar between the two groups.

Table 2. Operative data

Comparison	RAMT	UMS	P-value
Bioprosthesis suture valve			
Sutureless valve			
CPB time	116.3±51.7	92.90±26.365	0.001
ACC time	69.8±33.2	62.61±16	0.03
Mechanical ventilation time	10.7±9.1	13.7±12.6	0.273
Total operative time	137±49.2	163.1±48	0.537
Incisional wound	4.6 ± 0.5	8.6±0.4	< 0.001
Postoperative pain score ***At ACVICU*** ***One week postoperative*** ***One month postoperative***	 *5.3±1.1* *1.7±0.65* *1.5±0.5*	 *4.5±1.3* *1.5±0.9* *1.3±0.7*	 *< 0.001* *0.019* *0.012*

Discussion

MIS-AVR procedure was first described by *Cosgrove and Sabik* in *1996*; however it was not widely spread because of difficult access and exposure. Because of widespread of TAVI by intervention cardiologists, MIS-AVR interest returned back to scope of cardiac surgery [6].

In the beginning of MIS-AVR increased surgical times, increases the complexity of procedure, prolongs ACC and CPB times and, as *Denton Cooley* said, transfers the pain from the patient to the surgeon! [7].

With progress of learning curve and acquired experience of MIS-AVR, it is the preferred, safe, less traumatic, less morbidity, and enhanced recovery. It reduced blood loss, reduced transfusion requirements, reduced hospital stay and improved aesthetic appearance [8].

MIS-AVR is associated with improved survival, despite longer myocardial ischemic times than FS. Its advantages include early mobilization, less postoperative pain, excellent aesthetic results, and lower incidence of wound complications, especially in high-risk, obese, diabetic or elder osteoporotic patients [5].

MIS-AVR through an UMS was considered feasible in almost every patient. However, an RAMT required suitable anatomy, and this should be evaluated preoperatively through a chest computed tomography (CT) [6].

SURD-AVR was associated with shorter operative times and an increased rate of less invasive approaches. Postoperative echocardiographic data showed similar valve pressure gradients between SURD-AVR and SAVR [2].

Our experience with *Perceval* valve in RAMT approach showed favorable clinical and hemodynamic results. Despite encouraging mid-term results, we need data documenting its long-term performance. Sutureless technology and its future evolutions might be considered as an alternative treatment option for AVR, especially in high-risk patients [5].

MIS-AVR has gained increasing popularity over the last 20 years by avoiding FS, subsequently reducing surgical trauma. It has cosmetic advantages and is particularly useful in frail patients who may suffer from a conventional FS and associated morbidities [9].

Conclusions

Our centers experience, in minimal invasive sAVR, is safe and effective. MIS, in general, has less operative time, ICU and hospital stay, and postoperative pain. Right anterior mini-thoracotomy is the first choice associated with more cosmetic appearance. However, for patients unsuitable for RAMT, upper mini-sternotomy can be performed safely without a difference in results. Moreover, UMS has the advantage of less postoperative pain and pleural complications.

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Conflict of Interest

None

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Abbreviations

SAVR: surgical\aortic valve replacement, AS: aortic stenosis, MIS: minimal invasive surgery, TAVI: transcatheter aortic valve implantation, UMS: upper mini sternotomy, RAMT: right anterior mini thoracotomy, FS: full sternotomy, CPB: cardiopulmonary bypass , ACC : aortic cross clamp, CT : computed tomography, TTE : transthoracic echocardiography, SURD-AVR: sutureless aortic valve replacement, ACVICU: adult cardiovascular intensive care unit, COPD: chronic obstructive pulmonary disease, BMI: body mass index, INR : international normalized ratio, TEE: Transesophageal echocardiography, CTA: computed tomography aortography, CABG: coronary bypass surgery, BAV: bicuspid aortic valve, CXR: chest x-ray. CO2: carbon dioxide. Afib: atrial fibrillation, SSI: surgical site infection.

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