Hybrid Therapy for Atrial Fibrillation - Optimizing Treatment Strategies

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Abstract
Endocardial atrial fibrillation (AF) ablation techniques enable one to characterize the underlying substrate in order to tailor the ablation procedure but these ablation lesions are not always transmural nor long lasting. Surgical AF ablation techniques, on the other hand, create reliable linear lesions but the lesion set is based on empirical assumptions rather than specific patient characteristics. Performed in combination, both approaches seem to be complementary as they overcome their mutual shortcomings. Several hybrid or convergent ablation strategies with the use of various energy sources have been described. Medium and long term results are encouraging, especially in challenging settings such as persistent AF and failed endocardial catheter ablations.

Introduction
According to the most recent Heart Rhythm Society(HRS)/European Heart Rhythm Society(EHRA)/European Cardiac Arrhythmia Society (ECAS) consensus statement, both the endocardial and stand alone surgical AF ablation approach can be considered in patients with symptomatic AF refractory or intolerant to at least one Vaughan-Williams class 1 or 3 antiarrhythmic drug (AAD) but the current evidence supporting surgical ablation is mainly based on expert consensus and clinical experience. The indication to perform an endocardial ablation in this kind of patients, however, is driven by results from randomized clinical trials and/or meta-analyses.1

As the strengths of both techniques seem to overcome their mutual weaknesses, several groups tried to combine both approaches in the hope to further improve results of AF ablation. This review article will first briefly review the current status of endocardial and surgical ablation techniques in order to better understand the rationale for a hybrid or convergent concept. The second part will focus on the several aspects of the hybrid AF ablation with the emphasis on techniques, follow-up and outcomes.

Endocardial AF Ablation
The cornerstone of endocardial AF ablation is an ablation strategy that targets the pulmonary vein (PV) and/or PV antrum whereby electrical isolation of the PV should be the goal.1 The one-year success rate of this approach is greater than 80% in patients with paroxysmal AF.2 Nowadays, unipolar radiofrequency (RF) is the most frequently used energy source to perform PV isolation. Cryoablation and laser are two alternatives.3,4 Whatever energy source used, the most frequent reason for AF recurrence after PV isolation remains PV reconduction.5 Long-term results of catheter ablation for paroxysmal AF are somewhat disappointing: in a recently published prospective study, sinus rhythm was maintained in only 46% of patients after the initial procedure without AAD during a median follow-up period of 5 years.6 As AF progresses from paroxysmal to persistent and longstanding persistent AF, the atrial substrate itself plays an increasingly important role in the maintenance of the arrhythmia.7 This may explain why PV isolation alone results in success rates of less than 25% in patients with persistent AF.8 To improve these results, one needs to modify the atrial substrate by creating linear lesions and/or ablating complex fractionated atrial electrograms (CFAE). Ablation procedures combining PV isolation with linear lesions and/or CFAE ablation in patients with (longstanding) persistent AF, seem to result in better outcomes than PV isolation alone but there is an important variation in success rates ranging from 11% to 75% and the incidence of istrogenic atrial tachycardias after these procedures is substantial (up to 40%).9,10 The creation of linear lesions was inspired by the surgical Cox-maze procedure for AF.11 These linear

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free from symptomatic AF and 80% off AAD.

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while interrupting macro-re-entrant circuits.

Surgical AF Ablation

The gold standard for the surgical treatment of AF is the Cox-
maze III procedure, also known as the “cut-and-sew” maze. This
operation involves the creation of numerous incisions in both atria
that would direct the sinus impulse propagation through the atria
while interrupting macro-re-entrant circuits. This procedure
results in impressive long term success rates with 92% of patients
free from symptomatic AF and 80% off AAD. Postoperative care
was standardized and included regular follow-up appointments with
ECG monitoring. Importantly, the use of holter monitors, pacemaker
interrogation, implantable monitoring devices, were not routine and
therefore the results most likely overestimate the success. Another
advantage of the surgical approach, is the possibility of removing the
left atrial appendage (LAA) which may help to decrease the risk for
stroke, especially in patients with a contraindication for warfarin. According to the HRS/EHRA/ECAS expert consensus statement on
catheter and surgical ablation of AF, stand-alone AF surgery
should be considered for symptomatic AF patients who are refractory
or intolerant to at least one Class 1 or 3 AAD, prefer a surgical
approach or have failed one or more attempts at catheter ablation.

Nevertheless, the Cox-maze III procedure did not gain widespread
implementation due to its complexity and technical challenge. As
an alternative to the surgical incisions of the cut-and-sew maze
and in an effort to simplify the procedure, several groups replaced
these incisions with linear lines of ablation. In 2004, Damiano et
al. introduced the Cox-maze IV procedure during which bipolar RF
devices were used to isolate the PVs and create linear lesions. This
procedure can be performed through a small thoracotomy but it still
requires cardiopulmonary bypass. There appears to be no difference
between the Cox-maze III and IV procedure in terms of the rate of
freedom from AF at 3, 6, and 12 months. The last decade has been marked
by a quest for new surgical ablation devices using unipolar and
bipolar RF, microwave, laser, cryoablation or high-frequency
ultrasound, that would enable the cardiac surgeon to perform a
curative lesion epicardially on the beating heart without the need
for cardiopulmonary bypass. Unfortunately, none of the currently
existing energy sources is able to guarantee reliable, transmurral lesions
in each and every patient. Another shortcomings of the epicardial
surgical approach, is the inability to map and selectively ablate any
re-entrant or focal tachycardia occurring during surgical AF ablation.

Current techniques for the minimally invasive surgical treatment of
stand-alone AF, result in success rates (defined as freedom from any
AF episode longer than 30 seconds off AAD) at 12 months from
65% to 92% in paroxysmal AF and from 67% to 80% in persistent AF.

The Hybrid AF Ablation Procedure: the Best of Two Worlds

Given the current knowledge about etiology and pathophysiology
of AF, an optimal ablation procedure for this arrhythmia would 4 isolate
the PVs permanently, 5 define the specific properties of the underlying
atrial electrical substrate in order to customize the subsequent
ablation strategy, 6 always create completely transmural linear lesions,
and be minimally invasive. To date, neither the endocardial approach
nor the surgical ablation procedure on its own is able to meet all
these criteria. However, both techniques seem to be complementary
as, performed in combination (hence the nomenclature “hybrid” or
“convergent” procedure), they bear the potential to overcome their
respective shortcomings. The epicardial surgical approach seems to
result in superior transmurality of the lesions, resulting in longlasting
PV isolation and permanent conduction block. 26 The endocardial AF
ablation procedure on the other hand, using multipolar catheters and
three-dimensional electroanatomical mapping systems, is the most
efficacious setting to guide substrate modification and ablation of
atrial tachycardias known to occur during the stepwise ablation of
persistent AF. 27

There appears to be a wide variation in the possible combinations
of epicardial surgical and transvenous endocardial techniques, lesion
sets, and follow-up used for hybrid or convergent AF ablation
procedures (Table 1 and 2).\textsuperscript{28} In 2010, Kiser et al. reported on a series of 28 patients with persistent or longstanding persistent AF (mean AF duration 8 years, and mean left atrial size 5.3 cm) who had failed medical management and underwent a combined surgical epicardial RF ablation and electrophysiological endocardial ablation.\textsuperscript{29} The surgical part of the procedure was performed using a transdiaphragmatic pericardioscopic approach via an incision below the xiphoid process. Linear epicardial lesions were created with an irrigated, unipolar RF ablation device to isolate the PV, the posterior wall of the left atrium (LA), and the ligament of Marshall (Fig. 1). In addition to this, three other linear lesions were performed: from the inferior right PV towards the coronary sinus (CS), from the right inferior PV towards the posterior wall of the LA, and the ligament of Marshall (Fig. 1). In addition to this, three other linear lesions were performed: from the inferior right PV towards the coronary sinus (CS), from the right inferior PV towards the posterior wall of the LA, and the ligament of Marshall (Fig. 1).

The subsequent endocardial approach, which was performed during the same procedure, deployed comparable lesions to what has been reported by Kiser et al. except for the fact that CFAEs also were targeted. If AF organized into either atrial flutter (AFL) or atrial tachycardia during this stepwise approach, these arrhythmias were mapped and ablated. The endocardial endpoints of this procedure were entrance and exit block of the PVs, entrance block of the LA posterior wall, and block across mitral isthmus and CTI. Patients who remained in AF at the end of this procedure were cardioverted. A class 1 or class 3 AAD was initiated in all patients postoperatively and not stopped before 6 weeks. There were 6 major complications: 2 deaths, 2 rebleedings requiring reoperation and 2 pericardial tamponades. Patients were followed with 24-hour Holter at 3 months, and 24-hour or 7-day follow-up of minimally invasive epicardial bilateral PV isolation and endocardial AF ablation procedure. The first steps of this procedure consisted of gaining endocardial access to the LA after a transseptal puncture via a femoral venous approach and ablated these zones. The next step was to prove isolation of the PVs and posterior LA using a multipolar circular catheter placed endocardially. If high-frequency electrical activity was mapped at the endocardial surface of the CS, this was subsequently ablated. Finally, the cavotricuspid isthmus (CTI) was ablated endocardially with confirmation of bidirectional block. If sinus rhythm was not attained at the end of the procedure, the patient underwent cardioversion. The procedure was complicated by symptomatic pericardial effusion requiring percutaneous drainage in 2 patients and 1 patient had phrenic nerve paresis. Antiarrhythmic drugs were initiated after the procedure at the discretion of the electrophysiologist but discontinued by 3 months. Follow-up was performed with a 24-hour Holter at 3 months, and 24-hour or 7-day Holter at 6 months. At 3 months 87% of patients were in sinus rhythm, but only 43% were free of AF and AADs. At 6 months, 84% were in sinus rhythm, and 76% were free of AF and AAD.

Gehi et al. described a cohort of 101 consecutive patients who underwent a transdiaphragmatic pericardioscopic, hybrid epicardial-endocardial AF ablation procedure.\textsuperscript{30} Patients were considered for this procedure if they had (1) paroxysmal or persistent AF and failed prior endocardial catheter ablation with concomitant class 1 or class 3 AAD therapy, (2) persistent AF with dilated LA or structural heart disease, or (3) longstanding persistent AF. The epicardial surgical part of the procedure was performed with the same device and lesion set as described by Kiser et al.\textsuperscript{29} The subsequent endocardial approach, which was performed during the same procedure, deployed comparable lesions to what has been reported by Kiser et al. except for the fact that CFAEs also were targeted. If AF organized into either atrial flutter (AFL) or atrial tachycardia during this stepwise approach, these arrhythmias were mapped and ablated. The endocardial endpoints of this procedure were entrance and exit block of the PVs, entrance block of the LA posterior wall, and block across mitral isthmus and CTI. Patients who remained in AF at the end of this procedure were cardioverted. A class 1 or class 3 AAD was initiated in all patients postoperatively and not stopped before 6 weeks. There were 6 major complications: 2 deaths, 2 rebleedings requiring reoperation and 2 pericardial tamponades. Patients were followed with 24-hour Holter monitoring at 3, 6 and 12 months. Recurrence of AF was defined as any episode of AF lasting more than 30 seconds off all AADs. Recurrences occurring prior to the 3-month follow-up were not taken into consideration. Overall, 12-month arrhythmia-free survival after a single hybrid procedure off AAD was 68% and 73% including repeat endocardial ablation.

We published in 2012 our initial experience with long-term follow-up of minimally invasive epicardial bilateral PV isolation and linear lesions in combination with endocardial proof of conduction block and endocardial touch-up if indicated in a single AF ablation procedure in a cohort of 26 consecutive patients.\textsuperscript{11} Inclusion criteria were previously failed catheter ablation, LA volume \( \geq 29 \text{ ml/m2} \), persistent or longstanding persistent AF, or patient preference for a hybrid procedure. The first steps of this procedure consisted of gaining endocardial access to the LA with a transseptal puncture via femoral venous approach and thoracoscopic isolation of the PVs as ipsilateral pairs using a bipolar RF clamp (Fig. 2). If AF didn’t terminate or was still inducible after PV isolation, a roof line and an inferior line were created with a bipolar RF linear pen device. By making those linear lesions, the posterior LA was isolated which is also known

### Table 1: Hybrid AF ablation: baseline characteristics

<table>
<thead>
<tr>
<th>First author</th>
<th>Number of patients</th>
<th>Age (years)</th>
<th>LA diameter (cm)</th>
<th>CA (%)</th>
<th>Par AF N (%)</th>
<th>Pers AF N (%)</th>
<th>LS Pers AF N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiser</td>
<td>28</td>
<td>ns</td>
<td>5.3</td>
<td>0</td>
<td>0</td>
<td>5(18)</td>
<td>23(82)</td>
</tr>
<tr>
<td>Gehi</td>
<td>101</td>
<td>63±10</td>
<td>5.1±1.0</td>
<td>36(36)</td>
<td>17(17)</td>
<td>47(46)</td>
<td>37(37)</td>
</tr>
<tr>
<td>Pison</td>
<td>26</td>
<td>57±9</td>
<td>4.3±0.5</td>
<td>11(44)</td>
<td>15(57)</td>
<td>10(38)</td>
<td>1(5)</td>
</tr>
<tr>
<td>Muneretto</td>
<td>24</td>
<td>63±9</td>
<td>5.0±0.8</td>
<td>ns</td>
<td>3(12)</td>
<td>21(88)</td>
<td></td>
</tr>
<tr>
<td>Gersak</td>
<td>50</td>
<td>56±11</td>
<td>4.8±0.5</td>
<td>ns</td>
<td>3(6)</td>
<td>8(16)</td>
<td>39(78)</td>
</tr>
<tr>
<td>mahapatra</td>
<td>15</td>
<td>59±2</td>
<td>5.2±1.0</td>
<td>15(100)</td>
<td>0</td>
<td>9(60)</td>
<td>6(40)</td>
</tr>
<tr>
<td>Krul</td>
<td>31</td>
<td>57</td>
<td>4.7±0.7</td>
<td>14(45)</td>
<td>16(52)</td>
<td>13(42)</td>
<td>2(6)</td>
</tr>
</tbody>
</table>

Age and left atrial (LA) diameter expressed as mean ± SD. See text for details. AF = atrial fibrillation, CA = catheter ablation, LS = longstanding, N = number, ns = not specified, Par = paroxysmal, Pers = persistent
Acenocoumarol and AADs were discontinued after the 6-month procedure, and patients reinitiated their pre-operative AAD regimen. No deaths or conversions to cardiopulmonary bypass were reported. After the procedure, patients underwent a 7-day continuous Holter monitoring at 3, 6, 9, and 12 months. According to current guidelines, success was defined as no episode of AF/AFL/atrial tachycardia (AT) lasting more than 30 seconds off AAD after the 3-month blanking period. One-year success was 93% for patients with paroxysmal AF and 90% for patients with persistent AF.

Several groups analyzed the feasibility and effectiveness of a staged hybrid procedure. This means that the epicardial surgical and transvenous endocardial approach are performed in 2 separate procedures with an interval of at least several days.

Mureretto et al performed a staged hybrid AF ablation procedure in 24 consecutive patients with lone persistent or longstanding persistent AF. The mean LA dimension was 50 mm and the mean AF duration was 83 months. The surgical procedure was performed first and consisted of a monolateral, right-sided, thoracoscopic approach to deliver a continuous lesion encircling ‘en bloc’ the ostium of all PVs and the posterior wall of the LA (Fig. 4). This lesion was applied using a internally cooled, RF monopolar device with suction adherence. Once the box lesion had been completed, the presence of entrance and exit block was assessed using a quadripolar catheter placed in the middle of the lesion epicardially and a decapolar CS catheter. Bidirectional block was achieved in 88% of the patients. At the time of the surgical procedure, all patients were equipped with an implantable subcutaneous loop recorder. No surgical complications were reported. The endocardial ablation procedure was performed 30 to 45 days after surgery. In 21% of the patients, bidirectional block could not be confirmed at the level of the box lesion due to gaps which were subsequently closed using endocardial ablation catheters. In 62% of patients, additional endocardial lesions were deployed at sites of focal triggers for AF, CFAE and CTI. During follow-up the implantable loop recorder was interrogated monthly. In this study, AF recurrence was defined as the presence of AF with a duration longer than 5 minutes. At a mean follow-up of 28 months, 87% of the patients had no AF recurrence and 75% were off AAD.

In a recent paper, Gersak et al reported the outcomes of a convergent AF ablation procedure in 50 patients with mainly persistent or longstanding persistent AF. In 34 patients, the endocardial part of the procedure was performed during the same session. In the remaining 16 patients (32%), this was done at least two months after epicardial ablation (staged manner). In all patients the epicardial surgical ablation was performed first. The posterior surface of the heart was accessed via an endoscopically created, transdiaphragmatic pericardial window. The epicardial LA lesions were created without dissecting the pericardial deflections and using a vacuum irrigated bipolar RF catheter. Bidirectional block was achieved in 88% of the patients. At the time of the surgical procedure, all patients were equipped with an implantable subcutaneous loop recorder. No surgical complications were reported.

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AFL was induced, it was mapped and ablated. Once sinus rhythm was restored, PV isolation and block across linear lesions were assessed. If AF was induced, CFAEs were ablated after validation of PV isolation and completeness of linear lesions. There were no acute complications. Amiodarone was continued until 3 months. In the 30 patients from the catheter-alone control group, the ablation strategy included, at a minimum, antral PV isolation, roof line and CTI line. Patients were followed with 7-day Holter at 3, 6, and 12 months and 24-hour Holter at 9, 18 and 24 months. The primary endpoint was event free survival of any atrial arrhythmia longer than 30 seconds off AAD. After a mean follow-up of 20.7±4.5 months, 87% of patients in the sequential hybrid ablation group were free of any atrial arrhythmia off AAD, compared to 53% in the control group.

The feasibility of a completely epicardial hybrid procedure has also been investigated. Krul et al. performed thoracoscopic PV isolation, GP ablation and linear lesions (only in nonparoxysmal AF patients) in combination with epicardial assessment of conduction block during the same procedure in 31 patients (15 persistent or longstanding persistent AF).

Mahapatra and colleagues matched 15 patients with persistent or longstanding persistent AF who underwent a sequential hybrid ablation procedure and had previously failed at least 1 catheter ablation and 1 AAD to 30 patients who had failed at least 1 catheter ablation and were scheduled for a repeat catheter ablation only.

(34) The epicardial surgical ablation was performed with a bilateral thoracoscopic approach, using a bipolar RF clamp and a bipolar unidirectional RF ablation device (Fig. 6). Surgical ablation included isolation of the PVs and SVC, creation of a roof line, mitral isthmus line, GP ablation, ligament of Marshall ablation, and LAA exclusion. All patients were then loaded on amiodarone intravenously. Approximately 4 days later, patients underwent an endocardial ablation procedure. After confirmation of SVC isolation, CTI and CS ablation was performed and isoproterenol was administered. If

Table 2: Hybrid AF ablation: procedural characteristics and endpoints

<table>
<thead>
<tr>
<th>First author</th>
<th>Access</th>
<th>Epicardial energysource</th>
<th>Endocardial energysource</th>
<th>GP</th>
<th>LAA</th>
<th>Follow-up</th>
<th>Endpoint</th>
<th>Success percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiser</td>
<td>TD</td>
<td>Irrigated unipolar RF</td>
<td>ns</td>
<td>no</td>
<td>no</td>
<td>24-hour or 7-day Holter at 6 months</td>
<td>No AF off AAD</td>
<td>761</td>
</tr>
<tr>
<td>Gehi</td>
<td>TD</td>
<td>Irrigated unipolar RF</td>
<td>Noncooled 8-mm or cooled 3.5-mm tip</td>
<td>no</td>
<td>no</td>
<td>24-hour Holter at 3, 6, and 12 months</td>
<td>No episode of AF &gt; 30 seconds off AAD</td>
<td>731</td>
</tr>
<tr>
<td>Pison</td>
<td>TOB</td>
<td>Bipolar RF</td>
<td>Cooled 3.5-mm tip</td>
<td>no</td>
<td>yes</td>
<td>7-day Holter at 3, 6, 9, and 12 months</td>
<td>No episode of AF/AFL/AT &gt; 30 seconds off AAD</td>
<td>PAF 93, Pers AF 90</td>
</tr>
<tr>
<td>Muneretto</td>
<td>TOM</td>
<td>Irrigated unipolar RF</td>
<td>ns</td>
<td>no</td>
<td>no</td>
<td>Monthly interrogation of ILR</td>
<td>No episode of AF &gt; 5 minutes off AAD or AF burden &gt; 0.5%</td>
<td>751</td>
</tr>
<tr>
<td>Gersak</td>
<td>TP</td>
<td>Irrigated unipolar RF</td>
<td>Cooled 3.5-mm tip</td>
<td>no</td>
<td>no</td>
<td>Interrogation of ILR at 6, 12, and 24 months</td>
<td>SR off AAD</td>
<td>671</td>
</tr>
<tr>
<td>mahapatra</td>
<td>TOB</td>
<td>Bipolar RF</td>
<td>Noncooled 5-mm or cooled 3.5-mm tip</td>
<td>yes</td>
<td>yes</td>
<td>7-day Holter at 3, 6, and 12 months</td>
<td>No episode of AF/AFL/AT &gt; 30 seconds off AAD</td>
<td>871</td>
</tr>
<tr>
<td>Krul</td>
<td>TOB</td>
<td>Bipolar RF</td>
<td>ns</td>
<td>no</td>
<td>yes</td>
<td>24-hour Holter every 3 months during 2 years</td>
<td>No episode of AF/AFL/AT &gt; 30 seconds off AAD</td>
<td>PAF 92, Pers AF 90</td>
</tr>
</tbody>
</table>

1Global success percentage, 2Success percentage for patients with paroxysmal AF (PAF) en persistent AF (Pers AF). See text for details.

AAD = antiarrhythmic drugs, AF = atrial fibrillation, AFL = atrial flutter, AT = atrial tachycardia, GP = ganglionated plexi, ILR = implantable loop recorder, LAA = left atrial appendage, ns = not specified, TOB = thoracoscopic bilateral, TOM = thoracoscopic monolateral, TP = transdiaphragmatic pericardioscopic, SR = sinus rhythm.
sinus rhythm off AAD. Patients were followed up with a 24-hour Holter every 3 months. The primary endpoint was freedom from episodes of AF/AFL/AT lasting more than 30 seconds without the use of AAD after 12 months. Eighty-six percent of the patients reached this primary endpoint.

Discussion

The hybrid or convergent AF ablation procedure combines the best aspects of minimally invasive AF surgery and electrophysiology. This multidisciplinary approach makes it possible to create and evaluate an extensive biatrial lesion set, without sternotomy or cardiopulmonary bypass. To date, the number of patients who underwent a hybrid AF ablation remains small but, especially in patients with persistent and longstanding persistent AF, one-year success rates off AAD are promising. However, different hybrid or convergent ablation strategies, various energy sources and divergent definitions of success are being used which makes it quite difficult to compare outcomes. It is therefore not clear which lesions or lesion sets are needed and what is the best endpoint for this kind of procedures. The only lesion they all have in common is PV isolation. Isolation of the posterior wall of the LA is also a preferred target as ectopy initiating AF frequently arises in this part of the LA. The added value of GP ablation is still an area of debate. In an animal model, Damiano et al. demonstrated functional reinnervation within a period of 4 weeks. The concern has been raised that if this reinnervation is non-uniform, this could create a new substrate for AF that was not originally present in a given patient. Another advantage of the hybrid approach, is the possibility to exclude the LAA as this is the site of most of the clot formation that eventually leads to thromboembolic events in patients with non-valvular AF. In addition, there may be a small number of patients with recurrent AF owing to a trigger nestled in the LAA, which could be eliminated with exclusion of this appendage. Combining the epicardial surgical and the endocardial approach in one single procedure makes it possible to perform an endocardial touch-up whenever epicardial lesions are not completely transmural. Other advantages are [1] the anatomic guiding for those touch-up lesions by the surgeon showing the cardiologist where the epicardial lesions are exactly located and [2] the immediate add on endocardial lesion and the already deployed surgical lesions add up to form a firm transmural lesion. However, organizing this kind of procedures requires robust logistical capacities as both the cardiac surgeon and electrophysiologist need to be in the same room at the same time. Another important concern is that performing an endocardial ablation immediately after epicardial ablation rather than staging endocardial ablation at a later date, may limit endocardial mapping due to edema or transient injury caused by epicardial ablation. However, considering the long term results of the combined approach this probably is not a true problem. Whether to perform a hybrid AF ablation in a given patient rather than a standard endocardial procedure, remains a difficult question as long as we don’t have results of prospective randomized trials at our disposal. Current data suggest to reserve this kind of procedures for patients with persistent or longstanding persistent AF with a dilated LA or after a failed endocardial approach. The significant complication rate in some series is likely the effect of a learning curve as this kind of procedures requires a specific technical expertise concerning the epicardial surgical aspect. In order to further improve widespread acceptance and implementation of these hybrid techniques, major complications should be restricted to a minimum.

Conclusions:

Hybrid or convergent AF ablation procedures integrate the advantages of both cardiology and cardiac surgery. The surgeon is able to perform PV isolation epicardially, deploy a number of linear ablation lines and exclude the LAA. The electrophysiologist can realize endocardial validation of those epicardial lesions and perform endocardial (touch-up) ablation where necessary. There is a wide variation in surgical techniques and lesion sets. Although the number of patients treated so far is relatively small, the medium and long-term follow-up results are encouraging.
References:


