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# The Key Takeaways from the 2024 EHRA/HRS/APHRS/LAHRs Expert Consensus Statement on Catheter and Surgical Ablation of Atrial Fibrillation

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## ABSTRACT

The field of catheter and surgical ablation of atrial fibrillation (AF) has seen rapid advances in the past 7 years, necessitating an updated expert consensus document. This joint statement from the European Heart Rhythm Association (EHRA), Heart Rhythm Society (HRS), Asia Pacific Heart Rhythm Society (APHRS), and Latin American Heart Rhythm Society (LAHRS) provides a contemporary framework for patient selection and management for AF ablation.<sup>1,2</sup>

**Keywords:** Catheter ablation, Atrial fibrillation, Pulmonary vein isolation, Risk factor management, Mapping technologies

## Summary

The expert consensus statement begins by reviewing the classification and pathophysiology of AF. Definitions and types of AF are provided, along with an overview of the natural history and progression of the arrhythmia.<sup>3–6</sup> Key aspects of the molecular and electrophysiological mechanisms underlying AF initiation and maintenance are discussed, including the roles of triggers, rotational activity, multi-wavelet reentry, and autonomic influence.<sup>7,8</sup> The review also highlights the important structural and electrical remodeling changes that occur in the atria during the development and perpetuation of AF.<sup>9</sup>

Detailed anatomical considerations relevant to catheter ablation are then covered, including the typical pulmonary vein anatomy and variants, interatrial septum, left atrial architecture, coronary sinus, superior vena cava, autonomic ganglia, pericardial reflections, phrenic nerves, and esophageal course.<sup>10,11</sup> Understanding these complex anatomical relationships is crucial for safe and effective AF ablation procedures.

Indications for catheter ablation are comprehensively reviewed. Catheter ablation is recommended for symptomatic patients with paroxysmal, persistent, or long-standing persistent AF (Class I).<sup>12</sup> There is also a Class I recommendation for catheter ablation in patients with heart failure and AF to improve symptoms and prevent heart failure hospitalizations.<sup>13,14</sup> The document provides nuanced guidance on patient selection, taking into account factors like age, obesity, obstructive sleep apnea, and other comorbidities.<sup>15</sup> The consensus document then delves into the important topic of AF risk factors and preprocedural management. Hypertension, obesity, obstructive sleep apnea, excessive alcohol consumption, physical inactivity,

diabetes, and smoking are all highlighted as modifiable risk factors that should be addressed prior to ablation.<sup>16,17</sup> Preprocedural imaging to assess left atrial size and exclude thrombus is recommended, as are antiarrhythmic drugs and anticoagulation strategies.<sup>18</sup>

Detailed descriptions are provided for the various mapping and ablation tools available for catheter AF ablation. These include invasive contact and non-contact mapping techniques, non-invasive imaging modalities like electrocardiographic imaging and magnetic resonance imaging-based fibrosis guidance, and ablation energy sources such as radiofrequency, cryoablation, pulsed field, and laser.<sup>19,20</sup> The document also covers robotic and magnetic catheter navigation systems. Key biophysical principles, safety profiles, and efficacy data are summarized for each technology.<sup>21</sup>

The consensus document then delves into procedural management and ablation techniques in great detail. Topics covered include anesthesia and ventilation, vascular access, anticoagulation, transseptal puncture, use of intracardiac echocardiography, and esophageal temperature monitoring.<sup>22</sup> The core ablation strategy of pulmonary vein isolation is extensively discussed, with guidance on electrogram parameters, lesion quality indicators, waiting phases, adenosine testing, and first-pass isolation.<sup>23,24</sup> Adjunctive ablation targets beyond pulmonary vein isolation, such as linear lesions, complex fractionated electrograms, posterior wall isolation, and ganglionated plexi, are also reviewed.<sup>25,26</sup>

Postprocedural management is another key focus area. Recommendations are provided for anticoagulation, antiarrhythmic drug therapy, and rhythm monitoring protocols in the early and late phases after ablation.<sup>27,28</sup> The document emphasizes the phenomenon of early recurrences in the initial 3 months after ablation, discussing the underlying mechanisms and management strategies. Long-term patient follow-up is also covered, including the monitoring and treatment of atrial tachycardias that may develop.<sup>29</sup>

The consensus statement comprehensively addresses procedural outcomes, defining key success metrics like acute procedural success, AF recurrence, AF burden reduction, and AF progression.<sup>30</sup> It also highlights the importance of assessing patient-reported outcomes and quality of life.<sup>31</sup> Moreover, a thorough review of the potential complications associated with AF ablation, including strategies to minimize risk based on operator

experience, energy source, and ablation protocols. For each complication, both the minimum and maximum reported incidence rates are seen in Figure 1:

- Vascular complications have the highest incidence rate at 1–4%
- Cardiac tamponade follows at 0.4–1.3%
- Other complications show progressively lower rates
- Esophageal perforation has one of the lowest rates at 0.02–0.1%

### Incidence Rates of Complications

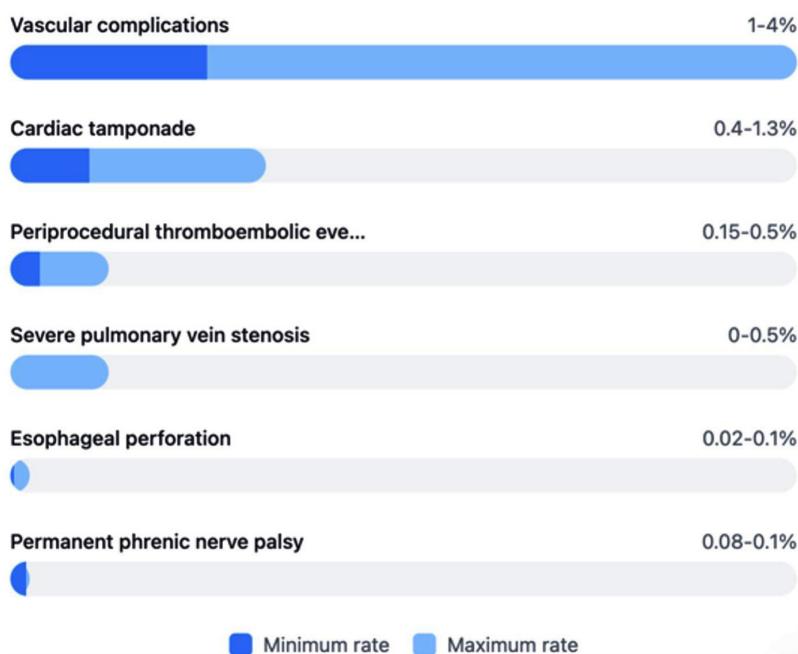


Fig 1 | Visualizes the incidence rates of various complications, with the data sorted from highest to lowest maximum incidence rate using a dual-color approach where the darker blue shows the minimum incidence rate and the lighter blue extends to show the maximum rate, giving a clear picture of both the baseline risk and the potential range for each complication

### Contribution of Predictors to AF Recurrence

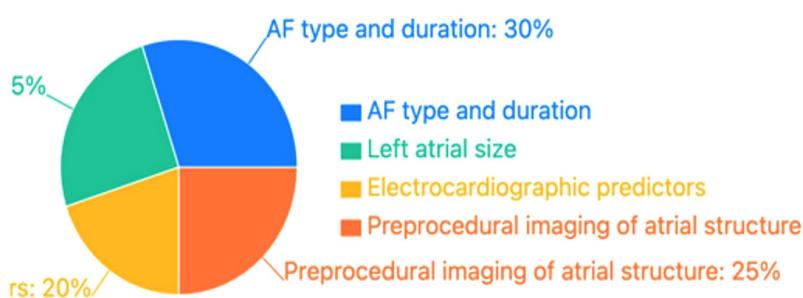


Fig 2 | Visualizes the incidence rates of various complications from highest to lowest maximum incidence rate using a dual-color approach where the darker blue shows the minimum incidence rate and the lighter blue extends to show the maximum rate, giving you a clear picture of both the baseline risk and the potential range for each complication

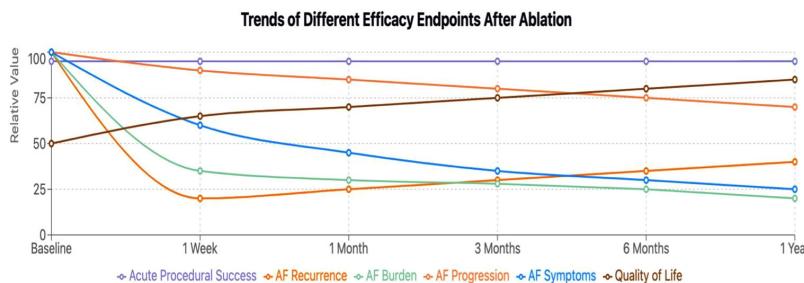
Regarding surgical ablation of atrial fibrillation, the document provides a comprehensive overview. Surgical techniques covered include the Cox-Maze procedure, hybrid ablation (combining catheter and surgical approaches), and minimally invasive surgical ablation.<sup>32,33</sup> The consensus highlights the role of surgical ablation for patients with long-standing persistent AF, those who have failed prior catheter ablation, and those undergoing concomitant cardiac surgery.<sup>34</sup> Key surgical principles, such as achieving complete electrical isolation of the pulmonary veins, addressing non-pulmonary vein triggers, and creating a bi-directional conduction block, are discussed in detail. Figure 2 shows both the minimum and maximum reported incidence rates:

- Vascular complications have the highest incidence rate at 1–4%
- Cardiac tamponade follows at 0.4–1.3%
- Other complications show progressively lower rates
- Esophageal perforation has one of the lowest rates at 0.02–0.1%
- Additionally, Figure 2 reveals that
- AF type and duration is the strongest predictor (30%)
- Left atrial size and Preprocedural imaging each contribute 25%
- Electrocardiographic predictors account for 20% of recurrence risk.

The document also addresses the important topic of pharmacological therapy in the context of catheter and surgical AF ablation. Guidance is provided on the use of antiarrhythmic drugs, anticoagulants, and other cardiovascular medications, both in the periprocedural period and during long-term follow-up.<sup>35,36</sup> Specific recommendations are made regarding the timing of discontinuation and reinitiation of these therapies.

Comprehensive quality of care and performance measures for AF ablation are outlined, encompassing both procedural and long-term outcomes.<sup>37</sup> These include acute procedural success, freedom from atrial arrhythmia recurrence, reduction in AF burden, avoidance of complications, improvement in symptoms and quality of life, and prevention of AF-related complications like stroke and heart failure.<sup>38</sup> The document emphasizes the importance of systematic data collection and reporting to drive continuous quality improvement.<sup>39</sup> Figure 3 shows how ablation procedures typically show immediate benefits (high acute success) while some measures like AF recurrence may gradually worsen, though still remaining significantly better than pre-procedure baselines. Other endpoints, such as an increase in the quality of life and a reduction in symptoms, show continued improvement over the follow-up period.

1. Acute Procedural Success: Remains consistently high (95%) throughout the follow-up period, indicating the immediate technical success of the procedure.



**Fig 3 |** Shows the trends of different efficacy endpoints following ablation procedures from baseline through 1 year. The values are shown as relative percentages where higher values for “AF Recurrence,” “AF Burden,” “AF Progression,” and “AF Symptoms” indicate worse outcomes, while higher values for “Acute Procedural Success” and “Quality of Life” indicate better outcomes

2. AF Recurrence: Shows a gradual increase over time, starting very low immediately post-procedure but gradually rising to 40% at 1 year, illustrating the typical decline in efficacy over time.
3. AF Burden: Shows significant reduction from baseline, remaining low throughout the follow-up period, with continued improvement over time.
4. AF Progression: Demonstrates delayed progression, with a steady downward trend indicating the procedure’s effectiveness in slowing disease advancement.
5. AF-Related Symptoms: Shows consistent improvement (declining trend) across the follow-up period, with patients experiencing fewer symptoms over time.
6. Quality of Life: Displays steady improvement from baseline, rising consistently throughout the follow-up period.

Finally, the consensus statement addresses emerging technologies and future directions in the field of AF ablation. Areas highlighted for further research and development include advanced mapping techniques (e.g., body surface mapping, artificial intelligence-guided mapping), novel energy sources (e.g., pulsed-field ablation, microwave ablation), improved catheter design and navigation, and hybrid surgical-catheter approaches.<sup>40,41</sup> The document also calls for expanding the evidence base through large-scale, multicenter trials and registries, with a focus on long-term outcomes and comprehensive patient-centered assessments.

#### What Is New?

The 2024 EHRA/HRS/APHRS/LAQRS expert consensus statement on catheter and surgical ablation of atrial fibrillation represents a significant update compared to previous guidelines. Some of the key changes and new additions include:

1. Expanded indications for catheter ablation:
  - The consensus now provides a Class I recommendation for catheter ablation in patients with heart failure and atrial fibrillation to improve symptoms and prevent heart failure hospitalizations.
  - The guidance on patient selection is more nuanced, with detailed considerations for elderly

patients, those with obesity, and those with other comorbidities.

2. Increased emphasis on risk factor management:
  - The document places greater emphasis on the importance of addressing modifiable risk factors, such as hypertension, obesity, obstructive sleep apnea, and excessive alcohol consumption, prior to ablation.
  - Detailed recommendations are provided on the roles of lifestyle modifications and risk factor optimization in improving outcomes.
3. Comprehensive coverage of mapping and ablation technologies:
  - The consensus provides extensive reviews of the various mapping techniques, including invasive contact and non-contact methodologies, as well as non-invasive imaging modalities like electrocardiographic imaging and MRI-based fibrosis guidance.
  - It also covers the latest advancements in ablation energy sources, such as pulsed-field ablation and laser ablation, in addition to the more established radiofrequency and cryoablation techniques.
4. Refined procedural strategies and guidance:
  - The document delves deeper into the nuances of pulmonary vein isolation, including discussions on electrogram parameters, lesion quality indicators, and the role of adenosine testing.
  - It also provides more detailed recommendations on the use of adjunctive ablation targets beyond pulmonary vein isolation, such as linear lesions, complex fractionated electrograms, and ganglionated plexi.
5. Stronger emphasis on long-term outcomes and follow-up:
  - The consensus statement places greater emphasis on the importance of assessing patient-reported outcomes and quality of life as key success metrics, in addition to traditional arrhythmia-related endpoints.
  - It also provides more comprehensive guidance on the management of atrial tachycardias that may develop after initial ablation, as well as the role of repeat procedures.
6. Incorporation of surgical ablation techniques:
  - The 2024 consensus incorporates a dedicated section on surgical ablation of atrial fibrillation, including the Cox-Maze procedure, hybrid ablation, and minimally invasive surgical approaches.
  - This addition reflects the evolving role of surgical ablation, particularly for patients with long-standing persistent AF or those who have failed prior catheter ablation.

7. Identification of knowledge gaps and future directions:
  - The document acknowledges areas where further research is needed, such as the development of advanced risk stratification tools, the role of emerging technologies (e.g., artificial intelligence-guided mapping, novel energy sources), and the expansion of large-scale, multicenter trials and registries.
  - This forward-looking approach helps to set the agenda for ongoing innovation and optimization in the field of atrial fibrillation ablation.

These changes and additions to the 2024 expert consensus statement reflect the rapid evolution of the field and the need for up-to-date, evidence-based guidance to support healthcare professionals in the management of atrial fibrillation (Table 1).

#### What Is Lacking?

There are some areas for potential improvement in the 2024 EHRA/HRS/APHRS/LAQRS expert consensus statement on catheter and surgical ablation of atrial fibrillation as below:

1. Lack of strong evidence-based recommendations in certain areas:
  - The document relies heavily on expert opinion and lower-quality evidence in some sections, particularly regarding indications for ablation in specific patient subgroups (e.g., asymptomatic patients, patients with heart failure with preserved ejection fraction). More robust clinical trial data is needed to firmly guide decision-making in these complex scenarios.

**Table 1 | Provides a concise overview of the major topics covered in the 2024 expert consensus statement, highlighting the comprehensive nature of the guidance and the importance of detailed anatomical knowledge for successful AF ablation procedures**

Topic	Key Highlights
Definitions and Classifications	<ul style="list-style-type: none"> <li>• Detailed definitions of paroxysmal, persistent, and long-standing persistent AF</li> <li>• Emphasis on AF pathophysiology and progression</li> </ul>
Patient Selection for Ablation	<ul style="list-style-type: none"> <li>• Indications for catheter ablation in symptomatic patients with paroxysmal, persistent, or long-standing persistent AF</li> <li>• Considerations for patients with heart failure, the elderly, and other comorbidities</li> </ul>
Preprocedural Management	<ul style="list-style-type: none"> <li>• Importance of addressing modifiable risk factors (obesity, sleep apnea, alcohol, etc.)</li> <li>• Role of imaging, anticoagulation, and antiarrhythmic drugs</li> </ul>
Mapping and Ablation Technologies	<ul style="list-style-type: none"> <li>• Overview of contact and non-contact mapping, non-invasive imaging, and various energy sources (radiofrequency, cryoablation, pulsed field, laser)</li> </ul>
Procedural Techniques	<ul style="list-style-type: none"> <li>• Detailed guidance on pulmonary vein isolation, adjunctive ablation targets, and procedural workflow</li> </ul>
Postprocedural Management	<ul style="list-style-type: none"> <li>• Anticoagulation, antiarrhythmic drug use, and monitoring for early and late recurrences</li> </ul>
Outcomes and Complications	<ul style="list-style-type: none"> <li>• Definitions of procedural and long-term success, including patient-reported outcomes</li> <li>• Strategies to minimize ablation-related complications</li> </ul>
Surgical Ablation	<ul style="list-style-type: none"> <li>• Role of surgical techniques (Cox-Maze, hybrid, minimally invasive) in selected patients</li> </ul>
Future Directions	<ul style="list-style-type: none"> <li>• Emerging technologies (advanced mapping, novel energy sources) and the need for further research</li> </ul>

2. Insufficient detail on patient selection and risk stratification:
  - While the document discusses several clinical and imaging predictors of procedural outcomes, a more comprehensive risk stratification algorithm would be helpful to guide patient selection and set appropriate expectations.
  - Incorporation of recently developed risk scores and prediction models could strengthen the guidance in identifying optimal candidates for ablation.
3. Limited discussion of alternative ablation strategies:
  - The document focuses primarily on pulmonary vein isolation as the cornerstone of AF ablation, with limited detail on alternative approaches like substrate modification, linear lesions, and targeting of non-pulmonary vein triggers.
  - Greater coverage of the evolving evidence and optimal applications of these adjunctive ablation techniques would enhance the clinical utility of the consensus.
4. Insufficient emphasis on shared decision-making:
  - While the document acknowledges the importance of patient preferences, it could place a stronger emphasis on a collaborative, patient-centered approach to decision-making regarding AF ablation.
  - Incorporating tools and frameworks to facilitate shared decision-making between providers and patients would be a valuable addition.
5. Lack of implementation and health economic considerations:
  - The consensus statement does not adequately address the practical challenges and resource implications of the widespread adoption of AF ablation, particularly in areas with limited access to specialized centers and technologies.
  - Guidance on optimizing care delivery models, training pathways, and cost-effectiveness analyses would strengthen the real-world applicability of the recommendations.
6. Limited guidance on long-term follow-up and management of recurrences:
  - While the document discusses early recurrences after ablation, it could provide more detailed recommendations on long-term monitoring strategies, management of late recurrences, and the role of repeat procedures.
  - Incorporating patient-reported outcomes and quality-of-life assessments as key success metrics would also enhance the comprehensiveness of the guidance.
7. Need for more robust validation and external review:
  - Given the global scope of the consensus, further validation and external review by a broader,

more diverse group of stakeholders (e.g., primary care providers, healthcare administrators, patient advocates) would help ensure the recommendations are applicable across different healthcare settings and patient populations.

Addressing these areas of weakness would strengthen the clinical utility and impact of this expert consensus statement, ultimately improving the care and outcomes of patients with atrial fibrillation undergoing catheter or surgical ablation.

### Shared Decision-Making and Implementation

A notable gap in the current guidelines is the insufficient emphasis on shared decision-making. While the document acknowledges patient preferences, it could better emphasize collaborative approaches where patients actively participate in treatment decisions based on their values, preferences, and goals. Implementation challenges also need more attention, particularly regarding resource constraints, training pathways, and cost-effectiveness analyses to support the real-world application of these advanced techniques across diverse healthcare settings.

### Future Development and Trend

AF ablation appears poised for significant technological advancement and methodological innovation. Several key developments are likely to shape this field in the coming years.

Advanced mapping techniques, including body surface mapping and artificial intelligence-guided mapping systems, will likely enhance the precision of identifying arrhythmic substrates. Novel energy sources such as pulsed-field ablation and microwave ablation show promise for more effective and safer lesion creation. Catheter design may likely continue to evolve, with improvements in navigation systems potentially reducing procedure times and increasing efficacy. The hybrid approach combining surgical and catheter techniques may also become more standardized for complex cases, particularly for patients with long-standing persistent AF or those who have failed prior ablations. Additionally, there will likely be an expansion of the evidence base through large-scale multicenter trials and registries focusing on long-term outcomes and patient-centered assessments. These innovations collectively aim to improve procedural success rates, reduce complications, and enhance long-term freedom from arrhythmias while emphasizing quality-of-life improvements and symptom reduction as key metrics of success. As our understanding of AF pathophysiology deepens, treatment approaches will likely become more personalized, targeting specific mechanisms underlying each patient's arrhythmia.

### Conclusion

In summary, this 2024 expert consensus statement represents a major update to previous guidelines, reflecting the rapid evolution in the field of catheter and surgical AF ablation. It provides a robust, evidence-based framework to guide healthcare professionals in the appropriate

selection, management, and treatment of patients undergoing these procedures. Shared decision-making and implementation should not be forgotten. Key changes compared to prior guidelines include more detailed guidance on patient selection, expanded discussions of mapping and ablation technologies, refined procedural strategies, and a stronger emphasis on long-term follow-up and comprehensive outcome assessment.

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