

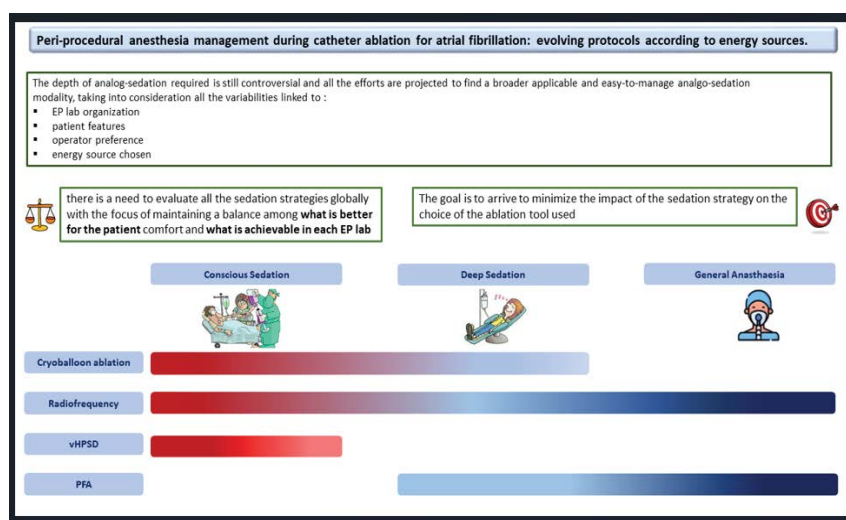


Review Article

Peri-procedural Anesthesia Management during Catheter Ablation for Atrial Fibrillation: Evolving Protocols According to Energy Sources

Sara Poggi MD^{1,5}, Assunta Iuliano MD^{1,5}, Giorgio Spiniello MD¹, Alessia Agresta MD², Francesco Solimene MD³, Antonio De Simone MD⁴, Giuseppe Stabile MD^{1*}

Graphical Abstract:



Keywords: Pulmonary vein isolation (PVI); Atrial fibrillation (AF); Anaesthesia; Deep sedation; Decision-making; Anesthesiologists

Introduction

Pulmonary vein isolation (PVI) is the mainstay of catheter ablation for atrial fibrillation (AF). In the last years, the number of patients undergoing catheter ablation of AF is continuously grew up, due to the high success rate of this procedure and the directions of the main guidelines [1,2].

This raises the issue of peri-procedural anesthesia management and how this impacts the electrophysiological (EP) Lab organization. The choice of the sedation strategy became a crucial element to take in consideration when the EP activity is planned. While the best modality of anesthesia is still a matter of debate, the always-growing demand of peri-procedural anesthesia management for AF ablation cannot be fully covered and performed by anesthesiologists in a number of EP Labs. Moreover, in some countries it is not permitted to perform deep sedation (DS) without the presence of an anesthesiologist [3]. Finally, patients' compliance to AF catheter ablation is strongly affected by the energy sources used in PVI. All together these issues influence the EP lab planning in terms of decision-making process for selecting an anesthesia modality.

Since the more painful phase of catheter ablation is related to energy delivery, the energy sources play a pivotal role in determining the sedation protocol. The aim of this review is to analyze the state of art of the peri-procedural sedation strategy, during AF catheter ablation, according to the energy sources for ablation.

Affiliation:

¹Mediterranea Cardiocentro, Napoli, Italy
²Villa del Sole, Salerno, Italy
³Casa di Cura Montevegine, Mercogliano (AV), Italy
⁴Casa di Cura San Michele, Maddaloni (CE), Campania, Italy
⁵IRCCS I.N.M. Neuromed, Pozzilli (IS), Italy

*Corresponding author:

Dr Giuseppe Stabile, Mediterranea Cardiocentro, via Orazio 2, 80122 Napoli, Italy.

Citation: Sara Poggi, Assunta Iuliano, Giorgio Spiniello, Alessia Agresta, Francesco Solimene, Antonio De Simone, Giuseppe Stabile. Peri-procedural Anesthesia Management during Catheter Ablation for Atrial Fibrillation: Evolving Protocols According to Energy Sources. *Anesthesia and Critical care*. 8 (2026): 40-44.

Received: February 20, 2026

Accepted: February 27, 2026

Published: March 20, 2026

Sedation Protocols

Three are the main sedation strategies used during AF ablation: conscious sedation (CS), DS, and general anesthesia (GA). Each of these strategies has specific advantages and drawbacks.

CS is defined as a condition in which the patient remains awake during the procedure and is able to respond to verbal commands, therefore not requiring airway management. The main advantage of this sedation modality is that it can be managed directly by the EP lab staff using small doses of analgesic drugs. Obviously, patient selection and motivation are two key elements that affect the success of this strategy. If pain is not optimally controlled, patient compliance can be lost, leading to significant respiratory variability and reduced quality of the ablation procedure. When a CS protocol is chosen, intra-procedural pain, discomfort, and anxiety can be easily assessed in real time, allowing the EP staff to switch to a deeper level of sedation only if necessary.

DP is defined as a condition in which the patient cannot be easily aroused but responds purposefully to repeated or painful stimulation. It may require assistance in maintaining a patent airway, but not necessarily endotracheal intubation. The main advantage of this approach is the ability to achieve effective pain control without the need for intubation. However, the main drawback is that it is difficult to manage this approach without the support of an anesthesiologist, which in practice limits its application.

GA is defined as a complete loss of consciousness requiring airway management through endotracheal intubation and positive-pressure ventilation. This strategy offers the important advantages of ensuring patient comfort and complete pain control, while allowing the electrophysiologist to operate on a motionless patient. This can translate into better catheter stability and higher quality of the ablation lesion [4]. However, potential complications may be detected late during GA, and additional risks—though rare—related to intubation or potential anaphylaxis must be considered. Furthermore, GA can be time- and resource-consuming [5], as not all EP labs have a dedicated recovery room, and this phase often takes place directly in the EP lab.

Another aspect that warrants consideration is that, in many countries, the distinction between DS and GA is often poorly defined, as the principal differences between these two modalities are frequently confined to airway management and anesthetic dosage. Consequently, GA and DS are commonly grouped together. This practice effectively restricts the implementation of both sedation protocols in numerous countries where national regulations permit cardiologists to rely exclusively on CS.

In the last decade, the proportion of procedures performed under GA and DS increased, whereas the use of CS decreased [3]. The most commonly used hypnotic drugs are propofol and

midazolam, whereas the most commonly used opioid drugs are remifentanyl and fentanyl. Sedation preference during AF ablation is based on anesthesiology accessibility, anesthesiologist preference, center protocol and patient characteristics [3,6] taking in consideration all the potential advantages and drawbacks of each modality.

Sedation Strategies with Thermal Sources

Thermal catheter ablation for AF includes both cryoballoon ablation (CBA) and radiofrequency (RF) and can be performed under all the three sedation strategies previously described. Although some studies found that patients undergoing AF ablation using GA were more likely to achieve freedom from AF recurrence [2,7,8], other studies have shown conflicting results regarding outcomes [9,10]. Recently, Massalha et al. [11] evaluated the impact of different anesthesia modalities on procedural outcomes and safety in AF ablation over 1002 patients: 53% received GA, 6.3% DS, and 40% CS, with CBA used in 84% of cases. No significant differences were found between CS and GA modalities in terms of AF recurrence rates at 12 months (15% vs. 16%) and 24 months (19.5% vs. 21.2%), or in 12-month re-hospitalization rates (19.8% vs. 16.5%). They concluded that CS was as safe and effective as GA in AF ablation, particularly with CBA. The choice of anesthesia appeared to be driven by patient characteristics and institutional factors without affecting long-term outcomes such as AF recurrence or complication rates.

Cryoballoon ablation. Cryoballoon ablation (CB) is widely used in the treatment of AF. If GA is often requested to reduce patient movements during the procedure, in the CBA immobilization is less essential so that each sedation protocol could be potentially used to provide patient comfort. Among the energy sources CBA seems to be the most versatile that could be carried out under all the three types of anesthesia according to the EP staff preference [12,13]. In a single center experience, Wasserlauf et al. [14] demonstrated that CBA can be performed under moderate sedation (using intravenous boluses of midazolam and fentanyl) resulting in comparable results in terms of success rates compared to GA, with shorter total EP laboratory time [15]. Mahmood et al. [16] described the largest cohort in comparing anesthetic approaches in CBA patients. They found that on multivariate analysis, freedom from any form of arrhythmias was not associated with the choice of the sedation protocol, with not differences between CS and GA. Recently, we demonstrated [17] that thermal catheter ablation for AF can be performed under conscious sedation using only morphine in most patients without impacting the patient's pain experience.

Radiofrequency: Radiofrequency delivery for PVI is usually associated with the need of electro-anatomical mapping (EAM) and this brings to significant longer procedural time [1] when compared with all the one-shot systems, both CBA

or pulsed field ablation (PFA). The longer is the procedure the more important is the compliance of the patient, his comfort and complete immobilization, in order to avoid problems as map shift, not optimal catheter contact, reduced accuracy of the ablation targets and increased possibility of postoperative complications. Attanasio et al. [18] showed that despite DS pain reactions often occur during RF ablation. Ablation with CBA was significantly less painful compared to ablation with RF energy. Knowledge of areas with more frequent pain reactions may help electrophysiologists to reduce pain reactions and related patient movements. Modification of sedation regimen during ablation, especially in the most painful regions, as the area of left inferior LSPV, could be considered. Nevertheless, Weinmann et al. [13] evidenced that CS in electro-anatomical mapping procedures appeared to be as safe as CS in CBA ablation.

Recently, the introduction of a new RF delivery strategy, the very high power short duration (vHPSD), changed the AF ablation scenario, because short-duration (4 s 90 W) applications results in a significant reduction in the procedural time and, more important, in the RF time, reducing the patient discomfort and maintaining the advantages of a point-by-point ablation [19,20]. Chu et al. [21] evaluated AF ablation with vHPSD using CS and compared it with CBA. The patient experience with vHPSD ablation under CS was very similar to that of CBA. Ablation using vHPSD was associated with significantly reduced ablation time for PVI compared to standard RF and CBA. Similarly, in 58 patients with paroxysmal AF, we [22] demonstrated that vHPSD RF ablation for PVI can be performed under CS sedation using only benzodiazepine in most of patients without compromising patient pain experience. In our study we found that an adequate preparation of the patient, verbal communication with him/her during the various steps of the procedural workflow and the presence of qualified personnel in the laboratory were important to guide the patient during the procedure; at the same time, the possibility to reduce the overall procedural time and the RF time by means of vHPSD, as compared to standard RF technology, seems to make the procedure more tolerable, with less discomfort of the patient and in general less amount of anesthesiologic drugs required to carry on the ablation procedure. The overall midazolam dose required in our experience was similar to that reported in Chu et al. [21] and was lower to that reported in series with CBA [18,23]. We [17] also evaluated the impact of the use of Morphine as first anesthetic drug during thermal AF ablation procedure in 109 patients undergoing CBA or vHPSD RF ablation. As already reported with CBA, also with vHPSD, ablation was performed under CS using only Morphine in most of patients without impacting patient pain experience.

Of particular mention is the possibility to resort to hypnosis during AF ablation procedure. The work by Scaglione et al. [24] demonstrated the potential benefits of hypnotic communication to facilitate AF ablation. They have found that

hypnotic communication during AF ablation was related to a significant reduction of intra procedural anxiety, perceived pain, procedural analgesic drugs dosage and perceived procedural duration without affecting total RF delivered time and procedural safety. They recently implemented their findings comparing the hypnotic communication during RF, vHPSD and PFA, reporting the feasibility and safety in all the three study groups [25]. It could be argued that the study population is small, thirty patients, and that it is a single center experience. This raises concerns that hypnotic communication could be taught to everyone could be equally effective among different hospitals.

Sedation Strategies with Pulsed Field Ablation

With the introduction of PFA, there has been a rapid development and widespread adoption of various ablation catheters, particularly one-shot systems. This evolution has generated considerable interest in the evaluation of workflow organization and sedation strategies aimed at optimizing procedures in electrophysiology laboratories. Although this novel ablation technology has demonstrated a favorable profile in terms of efficacy, safety, and reduced procedural times, the selection of the most appropriate sedation modality has emerged from the outset as a critical factor when PFA is employed. Overall, GA has appeared to be the most commonly adopted strategy. Indeed, the principal advantages of GA are twofold: improved catheter stability and complete pain control for the patient. This is particularly relevant for PFA applications, during which muscle contractions can be especially painful. In this evolving scenario, while the benefit of catheter stability associated with GA may no longer be essential with PFA systems—especially one-shot devices—the primary objective of the selected sedation strategy appears to be the achievement of complete pain suppression, combined with the most appropriate anesthetic approach available at each institution. This choice should take into account the presence of an anesthesiologist, institutional regulations, electrophysiology laboratory experience, as well as patient characteristics and comorbidities. Ciliberti et al. [26] investigated the impact of vHPSD and PFA on AF ablation workflow and organization. They found that PFA was associated with longer post-procedural times (because of extended patients monitoring due to prolonged anesthetic drug effects), pre-procedural time was the same in two groups, PFA guaranteed shorter procedural time as less lesions are needed to achieve PVI. Overall, total laboratory occupancy time was equal between RF and PFA. In this way, the possibility to resort to DS emerged as an interesting and relatively easy-to-apply alternative to GA. This strategy may help reduce the risks of complications, especially those due to intubation. The recent EU-PORIA sub analysis [27] about sedation strategies showed that the use of the penta-spline catheter for PFA was possible under DS demonstrating a safety and efficacy profile consistent with procedures performed under GA.

After the first launch of the PFA one-shot systems, recently focal PFA has started to spread. This new modality of PFA delivery combines the advantages of PFA with the versatility of the point-by-point ablation. Weyang et al. [28] demonstrated the feasibility of the use of DS in punctual PFA lesions, using the Centauri system. In all patients, the procedure were performed under DS, and intubation was not necessary for any patient. They adopted a protocol in which they precisely titrated the sedation to each patient's needs, with the goal of achieving the best possible balance between minimizing discomfort and pain and maintaining cardiorespiratory stability. These findings are in line with the experience of Hirokami et al. [29] that confirmed the feasibility of the ablation under DS with a novel lattice tip ablation catheter that can toggle between RF and PFA. Sochorová et al. [30], in the cooperative-PFA study, demonstrated that their approach based on remimazolam-ketamine DS was superior to propofol opioid regimens (either boluses or continuous) and had the lowest risk of hypoxemia (experienced in more than 80% of patients undergoing conventional opioid and propofol sedation) and hypotensive events.

Interestingly Calvert et al. [31] tested the feasibility of PFA under mild CS vs GA. Patients in the mild CS arm received bolus doses of midazolam and fentanyl. They concluded that PFA under mild CS was feasible in selected patients but pain and tolerance may be suboptimal, and high sedative doses are required. This is in contrast with what reported by Chen et al. [32] in their experience with a variable loop PFA catheter on 161 AF patients, founding no significant differences in effectiveness between CS and GA/DS.

Recently, Ding et al. [33] reported the improved tolerability profile of PFA using nanosecond application in a canine model. Nanosecond PFA yields comparable lesion durability, safety, and significantly reduced muscle contractions to microsecond PFA, which may help enable PVI without GA. This could be a possible direction to optimize the PFA usage and contributing to its complete diffusion.

However, the optimal depth of analgo-sedation remains controversial, and current efforts are directed toward identifying a broadly applicable and easily manageable analgo-sedation modality, while taking into account the variability related to electrophysiology laboratory organization, patient characteristics, and operator preference.

Conclusions

Nowadays, with the continuously increasing number of AF ablation procedures worldwide, there is a growing need to comprehensively evaluate sedation strategies, with the aim of maintaining an appropriate balance between optimal patient comfort and what is realistically achievable in each electrophysiology laboratory. This balance should be defined in accordance with local and institutional regulations, the

experience and confidence of the electrophysiology staff, and the energy source selected for ablation. The ultimate objective is to minimize the influence of the sedation strategy on the choice of the ablation technology.

References

1. Tzeis S, Gerstenfeld EP, Kalman J, et al. 2024 European Heart Rhythm Association/Heart Rhythm Society/Asia Pacific Heart Rhythm Society/Latin American Heart Rhythm Society expert consensus statement on catheter and surgical ablation of atrial fibrillation. *Europace* 26 (2024): euae043.
2. Van Gelder IC, Rienstra M, Bunting KV, et al. 2024 ESC guidelines for the management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J* 45 (2024): 3314-3414.
3. Garcia R, Waldmann V, Vanduyhoven P, et al. Worldwide sedation strategies for atrial fibrillation ablation: current status and evolution over the last decade. *Europace* 23 (2021): 2039-2045.
4. Di Biase L, Conti S, Mohanty P, et al. General anesthesia reduces the prevalence of pulmonary vein reconnection during repeat ablation when compared with conscious sedation: results from a randomized study. *Heart Rhythm* 8 (2011): 368-372.
5. Hummel JD, Elsayed-Awad H. Walking the tightrope between deep sedation and general anesthesia: by whom can this safely be done? *J Cardiovasc Electrophysiol* 22 (2011): 1344-1345.
6. Yamaguchi T, Shimakawa Y, Mitsumizo S, et al. Feasibility of total intravenous anesthesia by cardiologists with the support of anesthesiologists during catheter ablation of atrial fibrillation. *J Cardiol* 72 (2018): 19-25.
7. Riis-Vestergaard LD, Tønnesen J, Ruwald MH, et al. General anaesthesia compared to conscious sedation for first-time atrial fibrillation catheter ablation-a Danish nationwide cohort study. *Europace* 26 (2024): euae203.
8. Martin CA, Curtain JP, Gajendragadkar PR, et al. Improved outcome and cost effectiveness in ablation of persistent atrial fibrillation under general anaesthetic. *Europace* 20 (2018): 935-942.
9. Mahmoodi E, Leitch J, Davies A, et al. The importance of anaesthesia in atrial fibrillation ablation: comparing conscious sedation with general anaesthesia. *Indian Pacing Electrophysiol J* 23 (2023): 47-52.
10. Araújo B, Rivera A, de Oliveira Tapioca V, et al. Sedation vs. general anaesthesia in patients with atrial fibrillation undergoing catheter ablation: a systematic review and meta-analysis. *Europace* 27 (2025): euaf156.

11. Massalha E, Dakka A, Sabbag A, et al. Comparative analysis of anaesthesia modalities in pulmonary vein isolation: insights from a prospective multicentre registry. *Europace* 27 (2025): euac301.
12. Kuck KH, Brugada J, Fürnkranz A, et al. Cryoballoon or radiofrequency ablation for paroxysmal atrial fibrillation. *N Engl J Med* 374 (2016): 2235-2245.
13. Weinmann K, Heudorfer R, Lenz A, et al. Safety of conscious sedation in electroanatomical mapping procedures and cryoballoon pulmonary vein isolation. *Heart Vessels* 36 (2021): 561-567.
14. Wasserlauf J, Kaplan RM, Walega DR, et al. Patient-reported outcomes after cryoballoon ablation are equivalent between moderate sedation and general anesthesia. *J Cardiovasc Electrophysiol* 31 (2020): 1579-1584.
15. Wasserlauf J, Knight BP, Li Z, et al. Moderate sedation reduces lab time compared to general anesthesia during cryoballoon ablation for AF without compromising safety or long-term efficacy. *Pacing Clin Electrophysiol* 39 (2016): 1359-1365.
16. Mahmoodi E, Leitch J, Davies A, et al. The importance of anaesthesia in atrial fibrillation ablation: comparing conscious sedation with general anaesthesia. *Indian Pacing Electrophysiol J* 23 (2023): 47-52.
17. Poggi S, Strisciuglio T, Iuliano A, et al. Efficacy and safety of morphine during thermal catheter ablation of atrial fibrillation. *J Cardiovasc Med (Hagerstown)* 26 (2025): 649-655.
18. Attanasio P, Huemer M, Shokor Parwani A, et al. Pain reactions during pulmonary vein isolation under deep sedation: cryothermal versus radiofrequency ablation. *Pacing Clin Electrophysiol* 39 (2016): 452-457.
19. Reddy VY, Grimaldi M, De Potter T, et al. Pulmonary vein isolation with very high power, short duration, temperature-controlled lesions: the QDOT-FAST trial. *JACC Clin Electrophysiol* 5 (2019): 778-786.
20. Solimene F, Strisciuglio T, Schillaci V, et al. One-year outcomes in patients undergoing very high-power short-duration ablation for atrial fibrillation. *J Interv Card Electrophysiol* 66 (2023): 1911-1917.
21. Chu G, Calvert P, Sidhu B, et al. Patient experience of very high power short duration radiofrequency ablation for atrial fibrillation under mild conscious sedation. *J Interv Card Electrophysiol* 66 (2023): 445-453.
22. Poggi S, Strisciuglio T, Iuliano A, et al. Peri-procedural anesthesia and patient pain experience in pulmonary vein isolation by means of very high-power short-duration radiofrequency ablation. *J Interv Card Electrophysiol* 68 (2025): 141-147.
23. Miśkowiec D, Kasprzak JD, Wejner-Mik P, et al. Conscious sedation during cryoballoon ablation of atrial fibrillation: a feasibility and safety study. *Minerva Cardioangiologica* 66 (2018): 143-151.
24. Scaglione M, Battaglia A, Di Donna P, et al. Hypnotic communication for periprocedural analgesia during transcatheter ablation of atrial fibrillation. *Int J Cardiol Heart Vasc* 27 (2019): 100405.
25. Scaglione M, Spinoni EG, Pellegrini N, et al. Hypnosis for periprocedural analgesia during transcatheter pulsed field ablation of atrial fibrillation compared to conventional radiofrequency and very high power short duration ablation. *Europace* 27 (2025): euaf085.186.
26. Ciliberti D, Di Monaco A, Quadrini F, et al. Impact of pulsed field vs. radiofrequency on atrial fibrillation ablation workflow and organization: a single high-volume centre experience. *Europace* 27 (2025): euaf267.
27. Chun KRJ, Plank K, Neven K, et al. Characterization of sedation strategies in real-world use of pulsed field ablation: sub-analysis of the EU-PORIA registry. *Europace* (2025): euaf287.
28. Weyand S, Adam V, Biehler P, et al. Focal pulsed field ablation for atrial arrhythmias: efficacy and safety under deep sedation. *J Clin Med* 13 (2024): 576.
29. Hirokami J, Moser F, Schmidt B, et al. Feasibility of atrial linear ablation using a lattice tip catheter that toggles between radiofrequency and pulsed-field energy under deep sedation. *Heart Rhythm* 22 (2025): e40-e50.
30. Sochorová V, Kunštátová V, Osmančík P, et al. COOPERATIVE-PFA: a three-arm randomized controlled trial. *Circulation* 152 (2025): 150-159.
31. Calvert P, Mills MT, Murray B, et al. Feasibility of pulsed field ablation for atrial fibrillation under mild conscious sedation. *J Interv Card Electrophysiol* 68 (2025): 1429-1436.
32. Chen S, Liu Q, Yin X, et al. 12-month outcomes of pulsed-field ablation with a variable-diameter circular catheter for paroxysmal atrial fibrillation: insights into conscious sedation and fluoroscopy use. *Int J Cardiol* 429 (2025): 133135.
33. Ding L, Zhang A, Sun Y, et al. Nanosecond vs microsecond pulsed field ablation: lesion durability and muscle contraction in a canine model. *JACC Clin Electrophysiol* 11 (2025): 1218-1230.



This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC-BY\) license 4.0](https://creativecommons.org/licenses/by/4.0/)