Deep sedation with propofol in patients undergoing left atrial ablation procedures—Is it safe?

Leonie Foerschner, MD, Nada Harfoush, MS, Mara Thoma, MS, Lovis Spitzbauer, MR, Miruna Popa, MD, Felix Bourier, MD, Tilko Reents, MD, Verena Kantenwein, MD, Martha Telishevskaja, MD, Katharina Wimbauer, MD, Carsten Lennerz, MD, Elena Risse, MD, Amir Brkic, MD, Susanne Maurer, MD, Patrick Blazek, MD, Fabian Bahlke, MD, Christian Grebmer, MD, Christof Kolb, MD, Isabel Deisenhofer, MD, FHRS, Gabriele Hessling, MD, FHRS, Marc Kottmaier, MD

From the Department of Electrophysiology, German Heart Center Munich, Technische Universität Munich, Munich, Germany.

BACKGROUND Catheter ablation for atrial fibrillation (AF) or left atrial tachycardia is well established. To avoid body movement and pain, sedative and analgesic agents are used.

OBJECTIVE The aim was to investigate safety of sedation/anti-pain protocol administered by electrophysiology (EP) staff.

METHODS A total of 3211 consecutive patients (61% male) undergoing left atrial ablation for paroxysmal AF (37.1%), persistent AF (35.3%) or left atrial tachycardia (27.6%) were included. Midazolam, fentanyl, and propofol were administered by EP staff. In case of respiratory depression, endotracheal intubation (eIT) or noninvasive ventilation (NIV) was implemented. Risk factors for eIT or NIV were analyzed.

RESULTS Mean doses of propofol, midazolam, and fentanyl were 33.7 ± 16.7 mg, 3 ± 11.1 mg, and 0.16 ± 2.2 mg, respectively. Norepinephrine was administered in 396 of 3211 patients (12.3%) because of blood pressure drop (mean arterial pressure <60 mm Hg). NIV was necessary in 47 patients (1.5%) and eIT in 1 patient (0.03%). Procedure duration, high body mass index (BMI), high CHADS2-VASC2 score, high age, low glomerular filtration rate, diabetes mellitus, and low baseline oxygen saturation were associated with NIV or eIT. The only independent predictor for NIV/eIT was high BMI (>30.1 ± 9.0 kg/m²). Therefore, patients with a BMI of ≥30 had a 40% higher risk for the need of NIV/eIT during the procedure in our study.

CONCLUSION Sedation/anti-pain control including midazolam, propofol, and fentanyl administered by EP staff is safe, with only 1.53% requirement of NIV/eIT. High BMI (>30 kg/m²) emerged as an independent predictor for eIT/NIV.

KEYWORDS Ablation; Atrial fibrillation; Deep sedation; Propofol; Periprocedural anesthesia

Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia worldwide, with a rising prevalence as the population ages. For more than 15 years, catheter ablation including pulmonary vein isolation has been a well-established and effective treatment option for AF or atrial tachycardia. Progress in ablation tools and techniques as well as new electrocardiography (ECG) monitoring devices have significantly improved outcome of AF ablation.1

The aim of catheter ablation is to achieve optimal ablation accuracy within a short procedure time with minimal pain or complications for the patient. The ideal sedation technique is crucial to reach this aim.2 Currently, ablation procedures are generally conducted in 3 settings: (1) general anesthesia with endotracheal intubation, (2) deep sedation with propofol/midazolam, or (3) moderate/conscious sedation with fentanyl or midazolam.3 Several trials have shown that general anesthesia/deep sedation has a major impact on procedural success. For patients with AF undergoing pulmonary vein isolation, administration of general anesthesia increases safety and efficacy of the procedure and lowers rate of reconnections.4 In recent years, the combination of intravenous propofol and midazolam has been increasingly used to provide deep unconscious sedation.5 Using a combination of propofol and midazolam generates deep sedation, while fentanyl generates analgesia.5,6 Propofol is a safe anesthetic agent frequently used for induction of general anesthesia during major surgery, for sedation during mechanical ventilation in adults, and for interventions such as endoscopy.7,8 It binds to the GABA_A- and glycine-gated ion channels and thus agonizes and potentiates the inhibitory activity of the central
nervous system. Multiple additional targets for propofol that lead to loss of consciousness are suggested but not yet proven.\(^8\) Propofol has amnestic and antiemetic but no analgesic properties. Additional opioids are necessary to provide analgesia for left atrial radiofrequency ablation procedures for patients who undergo left atrial ablation procedures during this time frame since 2012. Patient mean age was 65.8 ± 11.6 years, 61% of patients were male, and the mean CHA\(_2\)DS\(_2\)-VASC score was 2.6 ± 1.7. Informed consent was obtained from all participants. The study was approved by the Ethics Committee (technical University Munich, Germany).

### Methods

#### Patient cohort

The study cohort included 3211 consecutive patients who underwent left atrial radiofrequency ablation procedures for paroxysmal AF (n = 1191, 37.1%), persistent AF (n = 1132, 35.3%), or left atrial tachycardia (n = 886, 27.6%) from June 2017 to May 2019 at our center. All patients undergoing left atrial ablation during this time frame received deep sedation with propofol, midazolam, and fentanyl and were included. None of the patients received elective general anesthesia. No patient had to be excluded from the study. Deep sedation with propofol, midazolam, and fentanyl has been used in our center since 2012.
procedure and on the following day to exclude pericardial effusions. All patients were checked for groin complications before discharge. Follow-up appointments for late bleeding or thromboembolic complications were performed 1 month after persistent AF and 3, 6, and 12 months after paroxysmal AF or atrial tachycardia ablation.

Equipment needed for resuscitation was available in the operating room. To support our team and in case of need for emergency intubation, an anesthetic consultant was available at any time in our EP laboratory. During the procedure, clinical data and all procedural steps including procedural duration (time from induction of sedation to sheath removal) were recorded. Vital signs including blood pressure, oxygen saturation, heart rate, and ECG were monitored and continuously recorded using a Philips vital signs monitoring system (IntelliVue MP5SC; Hamburg, Germany). Airway patency was maintained using an oropharyngeal Guedel airway tube and continuous oxygen therapy at 2–4 L/min via nasal cannula.

Deep sedation was initiated with midazolam (starting dose for patients <60 kg: 1 mg; for patients >60 kg: 2 mg) and a bolus of propofol (20–30 mg) with consequent continuous infusion of intravenous 1% propofol (weight adapted, 3–4 mg/kg/h; starting with 100–150 mg/h) by an EP nurse supervised by the operating physician (usually 1 cardiac electrophysiologist and 1 EP nurse in the room). The continuous infusion dose of propofol was elevated to 250–300 mg/h or higher until the Richmond Agitation and Sedation Scale (RASS) score of -4 was reached. A starting dose of 0.025–0.05 mg of fentanyl was administered to control discomfort or pain. An additional dose of 0.025–0.05 mg fentanyl was administered prior to the beginning of radiofrequency application. Additional fentanyl dose was adapted to patient’s weight, persistence of pain during the procedure, and procedure time. Medication dose was adapted to patient’s body weight. Deep sedation with propofol was maintained throughout the procedure. RASS was applied to evaluate the level of sedation. A RASS score of -4 was considered as deep sedation.

Periprocedural sedation-related complications
Development of hypoxemia or hypotension during the procedure was regarded as sedation-related complication. In case of mild transient oxygen saturation drop <95%, reclamation of the head, administration of Guedel airway tube, enhancement of oxygen therapy, and change from nasal cannula to oxygen mask was conducted. In case of severe persistent hypoxemia (oxygen saturation <85%, pH <7.25, and pCO2 >50 mm Hg), noninvasive ventilation (NIV) or endotracheal intubation (eIT) was implemented. Hypotension (MAP <60 mm Hg) was treated with norepinephrine infusion or a decrease in propofol infusion rate.

Statistical analysis
Categorical data are presented as frequencies and percentages. Continuous variables are presented as mean ± standard deviation. Statistical comparisons for categorical variables were performed using Fisher exact test. Univariate comparisons for continuous variables were performed using the Student t test. A P value of <.05 was considered to be statistically significant. Multivariate analysis was performed to detect predictive factors for NIV or eIT. All analyses were performed using SPSS (Version 27; IBM Corp, Armonk, NY).

Results
Baseline characteristics
Baseline characteristics of the 3211 patients are shown in Table 1. The mean age of patients (61% male) was 65.8 ± 11.6 years. Most of the patients had an elevated body mass index (BMI) (mean BMI 27.9 ± 4.9) and 868 of 3211 (27%) suffered from coronary artery disease or peripheral artery disease. The most common cardiac comorbidity was arterial hypertension (29.6%). The amount of clinically diagnosed obstructive sleep apnea (OSA) was not recorded. Nevertheless, OSA is often not diagnosed prior to ablation, since it is not systematically evaluated in our hospital. In a recently published study of from institution, “Role of the ambulatory assessed apnea-hypopnea index for predicting recurring atrial fibrillation after ablation therapy,” the apnea-hypopnea index was used to screen patients with OSA. The comparable patient collective of nearly 200 patients with paroxysmal or persistent AF showed 24.1% of patients with apnea-hypopnea index >15, as an indicator for moderate OSA. Consequently, we can assume similar incidence of OSA in our patient cohort.19

Procedural data are listed in Table 2. Mean procedural duration was 133.7 ± 52.7 minutes. Mean propofol dose was 440.7 ± 237.3 mg/h, mean midazolam dose was 3 mg ± 11.1 mg, and mean fentanyl dose was 0.16 ± 2.2 mg. Sufficient oxygen saturation was maintained in all patients during the procedure (mean oxygen saturation drop was 4.5% ± 27.5%). An additional 4F arterial sheath was used in 859 of 3208 patients (27.8%) for invasive blood
pressure control and/or for arterial blood gas analysis. Norepinephrine was administered in 396 patients (12.3%) because of blood pressure drop (MAP < 60 mm Hg). NIV had to be implemented in 47 patients (1.5%) but only 1 patient (0.03%) needed eIT. Sedation-related hypotensive events occurred in 396 patients (12.3%) and norepinephrine was administered to correct the hypotension.

Comparison of baseline characteristics/procedural data between patients with or without eIT/NIV is shown in Table 3. Compared to patients without sedation complications, patients needing eIT or NIV had significantly longer procedure durations, a higher BMI, and higher CHA2DS2-VASC score; were significantly older; had a lower glomerular filtration rate; suffered more often from diabetes mellitus; and had a lower baseline oxygen saturation.

Naloxone to reverse fentanyl was used in 27 cases (0.8%). The number of patients that required NIV or eIT received naloxone significantly more often (7/48; 14.5%) compared to patients without complications (20/3163; 0.6%; \( P < .001 \)). To reverse midazolam (9/3211; 0.3%), patients received flumazenil; again, patients that required NIV or eIT significantly more often received flumazenil (4/48; 8.3%) in comparison with patients without complications (5/3163; 0.2%; \( P < .001 \)).

In the multivariate analysis, all baseline characteristics were included as covariates. The analysis showed that an elevated BMI (\( \geq 30 \) kg/m\(^2\); OR 1.6; \( P = .03 \)) was the only independent predictor for eIT/NIV use. The subgroup analysis of patients showed that the absolute risk for the need of NIV/eIT in patients with a BMI < 30 was 0.27 whereas the absolute risk for patients with a BMI \( \geq 30 \) was 0.375, resulting in a relative risk of 1.4. Therefore, patients with a BMI of \( \geq 30 \) had a 40% higher risk for the need of NIV/eIT during the procedure.

### Discussion

In this study of a large patient population of > 3200 patients undergoing left atrial catheter ablation procedures, a protocol including propofol and midazolam for deep sedation as well as fentanyl for analgesia administered by EP staff was safe and had a low incidence of complications. Our center is experienced in deep sedation with propofol, midazolam, and fentanyl using deep sedation since 2012. EP nurses as well as operators received special instruction for cardiac sedation and participate in annual cardiac life support training. Unfortunately, until now, there has been no specific training for EP staff for cardiac sedation, as it is already available for endoscopic nurses. We strongly recommend to establish a standardized training for EP staff. Only 1 patient (0.03%) needed eIT and 47 patients (1.5%) required NIV because of a permanent oxygen saturation drop below 85%. These findings are in accordance with other studies that describe the use of propofol and other opioids like piritramide instead of fentanyl for catheter ablation. In the multivariate analysis, only an elevated BMI (\( > 30 \) kg/m\(^2\)) was an independent predictor for NIV/eIT. Other studies confirm these findings.

### Safety and side effects of propofol administered by EP staff

Propofol sedation is considered safe, and the most common (rare) side effect of propofol is hypotension. Other side effects include bradyarrhythmia, respiratory depression, and allergic reactions. High-dose propofol infusion has been associated with the “propofol infusion syndrome,” which is rare, but more severe and characterized by metabolic acidosis and circulatory collapse.

In 2012, Wutzler and colleagues investigated the safety of propofol during 424 ablation procedures. Oxygen saturation, blood gas, ECG, and blood pressure were assessed. No anesthesia-associated complications were observed. In our study, the risk of noninvasive ventilation or endotracheal intubation using a combination of propofol, midazolam, and fentanyl was very low. Norepinephrine was necessary in 12.3% of patients because of arterial hypotension. In line with these findings, Wutzler and colleagues observed an occasional decrease of oxygen saturation < 90% during deep sedation with propofol/midazolam for catheter ablation. The majority of patients were treated by a reduction or termination of propofol infusion, and respiratory via a breathing bag was necessary in < 5% of cases. At a dosage of 4 mg/kg/h propofol, systolic and diastolic blood pressure dropped. In the study of Salukhe and colleagues that assessed 1000 patients, only 1 patient needed 4 minutes of mechanical bag and mask ventilation during deep sedation with propofol and fentanyl for catheter ablation. In the position paper of the German Society of Cardiology on cardio-analgo-sedation, Tilz and colleagues regard a combination of fentanyl,

### Table 2 Procedural data

| Parameter                  | N (%) / mean (SD) |
|----------------------------|-------------------|
| Procedural duration        | 133.7 ± 52.7      |
| Creatinine (mg/dL)         | 1.1 ± 2.7         |
| EF (%)                     | 53.6 ± 10.8       |
| RF duration (min)          | 42.5 ± 20.6       |
| Fluoroscopy time (min)     | 8.9 ± 5.9         |
| Fluoroscopy dose (cGy/m²)  | 575.6 ± 976.1     |
| Total amount of propofol (mg)| 922.9 ± 499     |
| Propofol (mg/h)            | 440.7 ± 237.3     |
| Midazolam (mg)             | 3.0 ± 11.1        |
| Flumazenil (mg)            | 9 (0.3%)          |
| Fentanyl (mg)              | 0.16 ± 2.2        |
| Naloxone                   | 27 (0.8%)         |
| Heparin dose (IE)          | 15,015.7 ± 20,180.1|
| Mean ACT (s)               | 322 ± 39          |
| Min ACT (s)                | 289 ± 57          |
| Max ACT (s)                | 344 ± 58          |
| Baseline oxygen saturation (%) | 95 ± 4           |
| Lowest oxygen saturation (%) | 90 ± 4           |
| Norepinephrine administration | 396 (12.5%)     |
| eIT                        | 1 (0.03%)         |
| NIV                        | 47 (1.5%)         |

Continuous values are expressed as mean ± standard deviation. Categorical values are expressed as number (percentage).

ACT = activated clotting time; EF = ejection fraction; eIT = endotracheal intubation; NIV = noninvasive ventilation; RF = radiofrequency.
midazolam, and propofol appropriate for longer EP procedures. Potential risk factors for complications like higher age, BMI, or comorbidities should be considered and continuous oxygen supply via nasal cannula and equipment for intubation are potential strategies for those patients at risk. In summary, our and other studies found that deep sedation with propofol during catheter ablation is safe and has a low incidence of complications such as intubation or NIV.

In their review, Thomas and colleagues14 compared different sedation techniques for catheter ablation. The data were derived from cardiologists. According to our approach, sedation was performed by non-anesthesiologic staff under the supervision of cardiologists in the majority of cases. Procedures were performed in a setting where continuous monitoring and emergency equipment were available. Anesthesiologists were rapidly available for emergency assistance.14 Salukhe and colleagues22 stated that sedation with 2% propofol infusion administered by electrophysiologists without assisted ventilation is safe and effective. In several studies, deep sedation with propofol administered by nurses during EP and non-EP interventions was considered safe and feasible.24–26

### Conscious sedation vs deep sedation

Compared to conscious sedation with fentanyl/midazolam, deep sedation with propofol might lead to higher ablation accuracy and is more comfortable for the patient. In 2019, Li and colleagues3 indicated in a meta-analysis of 9 studies that catheter ablation under general anesthesia/deep sedation contains a higher likelihood of procedural success compared to conscious sedation. In 2011, Di Biase and colleagues27 reported on a total of 257 AF patients undergoing catheter ablation with either conscious sedation (fentanyl/midazolam) or general anesthesia. Procedures performed under general anesthesia / deep sedation showed a higher success rate with freedom from AF after a single procedure at 17 ± 8 months follow-up. As a conclusion, general anesthesia/deep sedation likely reduces the prevalence of pulmonary vein reconnection owing to better catheter stability and a lower risk of tissue edema. Deep sedation with propofol has therefore been suggested as favorable anesthetic technique for catheter ablation in several studies.3,23

### Predictors of NIV

In 2019, Veevenka and colleagues20 analyzed predictive factors and safety of NIV used in combination with propofol deep sedation during left atrial ablation procedures. In accordance with our results, procedural data from 252 patients using sedation with 1% propofol showed that increased BMI is a significant predictive factor for NIV (P = .008). Other significant predictive factors for NIV were high-dose propofol sedation (P = .010), persistent AF (P = .029), prolonged procedure time (P = .006), and presence of OSA (P < .001). No patient needed endotracheal intubation. In contrast

---

**Table 3** Baseline characteristics and procedural data in patients with or without sedation complications

| No complications n (%) / mean (SD) | eIT or NIV n (%) / mean (SD) | P value† |
|-----------------------------------|-----------------------------|---------|
| Total (N = 3211)                  |                             |         |
| Sex (male)                        |                             |         |
| Age (years)                       |                             |         |
| BMI (kg/m²)                       |                             |         |
| Creatinine (mg/dL)                |                             |         |
| GFR (mg/dL)                       |                             |         |
| CHA2DS2-VASc score                |                             |         |
| Hypertension                      |                             |         |
| Diabetes mellitus                 |                             |         |
| History of stroke                 |                             |         |
| CAD or PAD                        |                             |         |
| Congestive heart failure          |                             |         |
| GFR (mg/dL)                       |                             |         |
| Creatinine (mg/dL)                |                             |         |
| Baseline characteristics and procedural data in patients with or without sedation complications

Continuous values are expressed as mean ± standard deviation. Categorical values are expressed as number (percentage).

BMI = body mass index; CAD = coronary artery disease; EF = ejection fraction; eIT = endotracheal intubation; GFR = glomerular filtration rate; NIV = noninvasive ventilation; PAD = peripheral artery disease; RF = radiofrequency.

*Significant results are marked with an asterisk (*).
to our study, OSA was an independent factor for NIV analyzed by Cox regression (P = .016). In our study, the only independent predictive factor for NIV/eIT was a higher BMI (>30.1 kg/m²). Thus, patients with these risk factors should be treated with special care, including early preparation of mask ventilation or lower propofol dose. Vevereka and colleagues concluded that propofol deep sedation for patients undergoing left atrial ablation is safe. Additionally, using NIV in high-risk patients with OSA, high BMI, or long procedure duration might improve long-term procedure results.

Patients’ satisfaction with invasive procedures often correlate with their experience of pain and discomfort. Münkler and colleagues analyzed patient satisfaction with periprocedural sedation (propofol/midazolam) during catheter ablation administered by EP staff. Using a standardized questionnaire, he found that deep sedation was generally well tolerated, and patients showed a high satisfaction with such a protocol. Only few patients reported pain (7.7%) and postprocedural side effects (16.6%), e.g., nausea and episodes of headache. In conclusion, deep sedation with propofol seems to make the procedure better tolerable for patients.

**Limitations**

The study was retrospective by design and patients were not randomized to an alternative form of sedation. Our observations were limited to ablation of paroxysmal or persistent AF or left atrial tachycardia. We cannot transfer our findings to other cardiac interventions. However, we believe that this study containing more than 3000 patients has shown evidence that propofol sedation administered by EP staff is safe and feasible. Other studies showed that OSA was a relevant risk factor for NIV. Unfortunately, we did not screen our patients for OSA, because it is often not diagnosed prior to ablation and not systematically evaluated in our hospital.

**Conclusion**

In conclusion, deep sedation with propofol for catheter ablation administered by EP staff is safe, with a low incidence of NIV or eIT. The most common periprocedural complication was blood pressure drop leading to consecutive norepinephrine administration (in 396 of 3211; 12.3%). On multivariate analysis, the only independent predictive factor for NIV or eIT was a higher BMI. That should alert operators that patients with a BMI of ≥30.1 kg/m² are more likely to require NIV or eIT during catheter ablation procedures. Patients with a BMI >30 had a 40% higher risk for NIV or eIT, highlighting the importance of intensified weight control prior to ablation and special preparation of the procedure in those patients. This patient population should be treated with special care and early preparation of mask ventilation. Overall, deep sedation with propofol administered by EP staff is safe and well tolerated by patients.

**Funding Sources:** This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Disclosures:** The authors have no conflicts to disclose.

**Authorship:** All authors attest they meet the current ICMJE criteria for authorship.

**Patient Consent:** Informed consent was obtained from all participants.

**Ethics Statement:** The study was approved by the Ethics Committee of the Technical University Munich, Germany. The research reported in this paper adhered to the human research Helsinki Declaration as revised in 2013.

**Disclaimer:** Given her role as Associate Editor, Isabel Deisenhofer had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to Editors Nazem Akoum and Jeanne E. Poole.

**References**

1. Sacks D, Bäster B, Campbell CV, et al. Multisociety consensus quality improvement revised consensus statement for endovascular therapy of acute ischemic stroke. Int J Stroke 2018;13:612–632.
2. Knackstedt C, Schauerte P, Kirchhof P. Electro-anatomic mapping systems in arrhythmias. Euroseurope 2008;10(Suppl 3):iii28–iii34.
3. Li KHC, Sang T, Chan C, et al. Anaesthesia use in catheter ablation for atrial fibrillation: a systematic review and meta-analysis of observational studies. Heart Asia 2019;11:e011155.
4. Santangeli P, Lin D. Catheter ablation of paroxysmal atrial fibrillation: have we achieved cure with pulmonary vein isolation? Methodist DeBakey Cardiovasc J 2015;11:71–75.
5. Wutzler A, Rolf S, Huemer M, et al. Safety aspects of deep sedation during catheter ablation of atrial fibrillation. Pacing Clin Electrophysiol 2012;35:38–43.
6. Tang RB, Dong JZ, Zhao WD, et al. Unconscious sedation/analgesia with propofol versus conscious sedation with fentanyl/midazolam for catheter ablation of atrial fibrillation: a prospective, randomized study. Chin Med J (Engl) 2007;120:2036–2038.
7. Gasparović S, Rustemović N, Opacic M, et al. Clinical analysis of propofol deep sedation for 1,104 patients undergoing gastrointestinal endoscopic procedures: a three year prospective study. World J Gastroenterol 2006;12:327–330.
8. Walsh CT. Propofol: milk of amnesia. Cell 2018;175:10–13.
9. Miner JK, Burton JH. Clinical practice advisory: emergency department procedure sedation with propofol. Ann Emerg Med 2007;50:182–187.e1.
10. Stogianou D, Protopapas A, Protopapas A, Tziomalos K, L. is propofol the optimal sedative in gastrointestinal endoscopy? Acta Gastroenterol Belg 2018;81:520–524.
11. Wang D, Chen C, Chen J, et al. The use of propofol as a sedative agent in gastrointestinal endoscopy: a meta-analysis. PLoS One 2013;8:e53311.
12. Phillips W, Anderson A, Rosengreen M, Johnson J, Halpin J. Propofol versus fentanyl/midazolam for brief painful procedures in the emergency department: clinical and bispectral index scale comparison. J Pain Palliat Care Pharmacother 2010;24:349–355.
13. Ferreira AO, Torres J, Barajas E, et al. Non-anesthesiologist administration of propofol sedation for colonoscopy is safe in low risk patients: results of a noninferiority randomized controlled trial. Endoscopy 2016;48:747–753.
14. Thomas SP, Thakkar J, Kovoor P, Thigalingam A, Ross DL. Sedation for electrophysiological procedures. Pacing Clin Electrophysiol 2014;37:781–790.
15. Calkins H, Kuck KH, Cappato R, et al. 2012 HRS/EHRA/ECAS expert consensus statement on catheter and surgical ablation of atrial fibrillation: recommendations for patient selection, procedural techniques, patient management and follow-up, definitions, endpoints, and research trial design: a report of the Heart Rhythm Society (HRS) Task Force on Catheter and Surgical Ablation of Atrial Fibrillation. Developed in partnership with the European Heart Rhythm Association (EHRA), a registered branch of the European Society of Cardiology (ESC) and the European Cardiac Arrhythmia Society (ECAS); and in collaboration with the American College of Cardiology (ACC), American Heart Association (AHA), the Asia Pacific Heart Rhythm Society (APHRS), and the Society of Thoracic Surgeons (STS). Endorsed by the governing bodies of the American College of Cardiology Foundation, the American Heart Association, the European Cardiac Arrhythmia Society, the European Heart Rhythm Association, the Society of Thoracic Surgeons, the Asia Pacific Heart Rhythm Society, and the Heart Rhythm Society. Heart Rhythm 2012;9:632–696.e21.
16. Committee on Quality Management and Departmental Administration. Continuum of Depth of Sedation: Definition of General Anesthesia and Levels of Sedation/Analgesia. https://www.asahq.org/standards-and-guidelines/continuum-of-depth-of-sedation-definition-of-general-anesthesia-and-levels-of-sedationanalgesia. Accessed January 8, 2021.

17. Dumonceau JM, Riphaus A, Aparicio JR, et al. European Society of Gastrointestinal Endoscopy, European Society of Gastroenterology and Endoscopy Nurses and Associates, and the European Society of Anaesthesiology guideline: non-anesthesiologist administration of propofol for GI endoscopy. Endoscopy 2010;42:960–974.

18. Dumonceau JM, Riphaus A, Beilenhoff U, et al. European curriculum for sedation training in gastrointestinal endoscopy: position statement of the European Society of Gastrointestinal Endoscopy (ESGE) and European Society of Gastroenterology and Endoscopy Nurses and Associates (ESGENA). Endoscopy 2013;45:496–504.

19. Trenkwalder T, Grebner C, Tydecks M, et al. Role of the ambulatory assessed apnea-hypopnea index for predicting recurring atrial fibrillation after ablation therapy. Am J Cardiol 2021;149:36–41.

20. Vevecka A, Schwab C, Forkmann M, et al. Predictive factors and safety of noninvasive mechanical ventilation in combination with propofol deep sedation in left atrial ablation procedures. Am J Cardiol 2019;124:233–238.

21. Marik PE. Propofol: therapeutic indications and side-effects. Curr Pharm Des 2004;10:3639–3649.

22. Salukhe TV, Willems S, Drewitz I, et al. Propofol sedation administered by cardiologists without assisted ventilation for long cardiac interventions: an assessment of 1000 consecutive patients undergoing atrial fibrillation ablation. Europace 2012;14:325–330.

23. Tilz RR, Chun KJ, Deneke T, et al. Positionspapier der deutschen gesellschaft für kardiologie zur kardioanalgosedierung. Der Kardiologe 2017;11:369–382.

24. Jensen JT, Möller A, Hornslet P, Konge L, Vilmann P. Moderate and deep nurse-administered propofol sedation is safe. Dan Med J 2015;62:A5049.

25. Adler DG, Kawa C, Hilden K, Fang J. Nurse-administered propofol sedation is safe for patients with obstructive sleep apnea undergoing routine endoscopy: a pilot study. Dig Dis Sci 2011;56:2666–2671.

26. Furniss SS, Sneyd JR. Safe sedation in modern cardiological practice. Heart 2015;101:1526–1530.

27. 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 2011;8:368–372.

28. Münkler P, Attanasio P, Parwani AS, et al. High patient satisfaction with deep sedation for catheter ablation of cardiac arrhythmia. Pacing Clin Electrophysiol 2017;40:585–590.