Dexmedetomidine for sedation during epicardial ablation for ventricular tachycardia: a single-center experience

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Abstract

Background Epicardial approach to ventricular tachycardia (VT) ablation is mainly performed under general anesthesia (GA). Although catheter manipulation and ablation in the epicardial space could be painful, GA lowers blood pressure and may interfere with arrhythmia induction and mapping, and the use of muscle relaxants precludes identification of the phrenic nerve (PN). Moreover, an anesthesiologist's presence is required during GA for the whole procedure, which may not always be possible. Therefore, we evaluated the feasibility and safety of epicardial VT ablations performed under conscious sedation using dexmedetomidine in our center.

Methods Between January 2018 and January 2022, all patients who underwent epicardial VT ablation under continuous dexmedetomidine infusion were prospectively included in the study. All patients received premedication 30 min before the epicardial puncture with paracetamol (acetaminophen 10 mg/ml) 1000 mg and ketorolac 30 mg. Sedation protocol included an intravenous bolus of midazolam hydrochloride (0.03–0.05 mg/kg) followed by continuous infusion of dexmedetomidine (0.2–0.7 mcg/kg/h). In addition, an intravenous fentanyl citrate bolus (0.7–1.4 mcg/kg) was given for short-term analgesia, followed by a second dose repeated after 30 to 45 min. Sedation-related complications were defined in case of respiratory failure, severe hypotension, and bradycardia requiring treatment.

Results Sixty-nine patients underwent epicardial or endo-epi VT ablation under conscious sedation and were included in the analysis. The mean age was 65.4 ± 12.1 years; forty-six patients were males (66.6%). All patients had drug-refractory recurrent VT. Forty-seven patients (68.1%) had non-ischemic cardiomyopathy (NICM), 13 patients (18.9%) had ischemic-cardiomyopathy (ICM), and 9 patients (13%) had myocarditis. Standard percutaneous sub-xiphoid access was attempted in all patients. Non-inducibility of any VT was achieved in 82.6% (9/9 myocarditis, 10/13 ICM, 38/47 NICM, $n = 57/69$ patients), inducibility of non-clinical VT in 13% (3/13 ICM, 6/38 NICM, $n = 9/69$ patients), and failure in 4.3% (3/38 NICM, $n = 3/69$ patients). Although we observed procedural-related complications in five patients (7.2%), one transient PN palsy, two pericarditis, and two vascular complications, those were not related to the conscious sedation protocol. No respiratory failure, severe hypotension, or bradycardia requiring treatment has been observed among the patients.

Conclusions Prompt availability of anesthesiology support remains crucial for complex procedures such as epicardial VT ablation. Continuous infusion of dexmedetomidine and administration of midazolam and fentanyl seem to be a safe and effective sedation protocol in patients undergoing epicardial VT ablation.

Keywords Dexmedetomidine · Epicardial ablation · Anesthetic management · Conscious sedation · Ventricular tachycardia · Ventricular arrhythmia · Catheter ablation

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1 Introduction

Ablation of ventricular tachycardia (VT) is a challenging procedure, and it is associated with variable success rates [1]. Despite technology advancements and improved understanding of arrhythmia mechanisms, endocardial-only ablation's acute and long-term success rates remain modest in non-ischemic cardiomyopathy (NICM) and myocarditis. An

important reason for procedural failure in these settings is the deeper extension of the substrate within the endocardium or the involvement of the subepicardium and epicardium. In addition, the presence of epicardial substrates, their density, and distribution is increasingly recognized in several forms of scar-related cardiomyopathies [2–4]. Although the epicardial approach to VT ablation increases the success rate, it remains a challenging procedure, requiring peculiar anesthetic management. Patients presenting for epicardial VT ablation may have normal to severely reduced ventricular function, and anesthetic support may be particularly helpful for patients who need inotropic agents or mechanical hemodynamic assistance to tolerate the procedure. Moreover, epicardial access is painful, and patient movements may create electroanatomical mapping distortion or shift. Therefore, epicardial VT ablation is usually performed under general anesthesia (GA) [5]. However, several disadvantages need to be considered. Firstly, GA may suppress arrhythmia inducibility or impair hemodynamic stability during VT, limiting procedural endpoints. Secondly, neuromuscular blocking agents impede identifying the phrenic nerve (PN) course with high-output pacing. Finally, the availability of anesthesiologists or anesthesia operators confident with these procedures may be limited in the real world. Dexmedetomidine is a selective central α_2-agonist sedative agent [6]. It has been increasingly used for sedation and delirium treatment from sleep deprivation in an intensive care unit (ICU) and as sedation in patients undergoing cardiac surgery with minimal impairment of ventilation, well maintenance of arousability [7–9], and without proarrhythmic or negative inotropic effects [10–12]. The rationale of this single-center, prospective study was to evaluate the feasibility and acute safety of epicardial VT ablation performed under conscious sedation using midazolam and fentanyl followed by continuous dexmedetomidine infusion.

2 Methods

2.1 Patient population

This is a prospective, single-center study of consecutive patients who underwent epicardial VT ablation under conscious sedation from January 2018 to January 2022. Baseline clinical characteristics were collected from patient medical records. The study was conducted according to the Declaration of Helsinki, the Institutional review board approved the study, and all patients signed informed consent before the procedure.

2.2 Epicardial access, mapping, and ablation

All patients in this study underwent both first-line (direct epicardial or combined endo-epi) and second-line epicardial approaches for VT ablation. A direct epicardial approach was performed when ECG, anamnestic, and imaging data revealed features of the epicardial origin of VT. The second-line approach was performed after a failed endocardial ablation or when a previous endocardial mapping suggested an epicardial origin.

All procedures were performed in the usual sterile fashion in the electrophysiology lab. All patients received premedication 30 min before the epicardial puncture with paracetamol (acetaminophen 10 mg/ml) 1000 mg and ketorolac 30 mg. Sedation and analgesia drugs were initiated with an intravenous bolus of midazolam hydrochloride (0.03–0.05 mg/kg). An intravenous fentanyl citrate bolus (0.7–1.4 mcg/kg) was given for short-term analgesia, followed by another bolus (0.7–1.4 mcg/kg) after 30 to 45 min. The doses were repeated depending on the level of consciousness of the patients. Dexmedetomidine infusion rate ranged from 0.2 to 0.7 mcg/kg/h (Fig. 1). The doses of midazolam, fentanyl, and dexmedetomidine were based on previously published data [13–19]. The level of sedation was evaluated with the Ramsay Sedation Score [20]. However, throughout the whole ablation, an anesthesiologist was available on call. Two senior, fully trained cardiac electrophysiologists, dedicated circulating arrhythmia nurses, and one technician were in the lab. Hemodynamic parameters were continuously monitored, such as invasive blood pressure, pulse oximetry, respiratory rate, and urine output. All patients received oxygen at 2–4 l/min via a nasal cannula. If necessary, arterial blood gasses were analyzed but not routinely. In addition, one of the EP nurses examined the consciousness level throughout the procedure. Adverse events related to the sedation protocol were recorded. Severe bradycardia was defined as a heart rate < 45 bpm. Severe hypotension was defined as MAP < 60 mmHg. Hypoxia was defined as pulse oxygen saturation (SpO2) < 90%. After ablation, all patients were transferred to the cardiac ICU for at least 24 h, depending on the patient's general conditions.

The epicardial approach has been described by Sosa et al. [21]. Briefly, the pericardium was accessed using an epidural needle (Tuohy bevel, 18 gauge, 1.3 × 150 mm; Braun, Kronberg, Germany). The Tuohy needle was directed from the left para-xiphoid space under fluoroscopic guidance in the right anterior oblique/left anterior oblique (RAO/LAO), anterior–posterior, and lateral views cardiac silhouette. For anterior puncture, 15–30° declination was used during access; for inferior/posterior access, the needle was directed at 45° from the horizontal plane. As the needle penetrated through the fibrous pericardium, a contrast puff was delivered to demonstrate flow within the pericardial space. A guidewire was advanced into the pericardial space, with positioning confirmed in the RAO/LAO view (Fig. 2, Panel A and B). A progressive dilation with increasing-size sheaths (5F to 7F) was usually

Sedation protocol

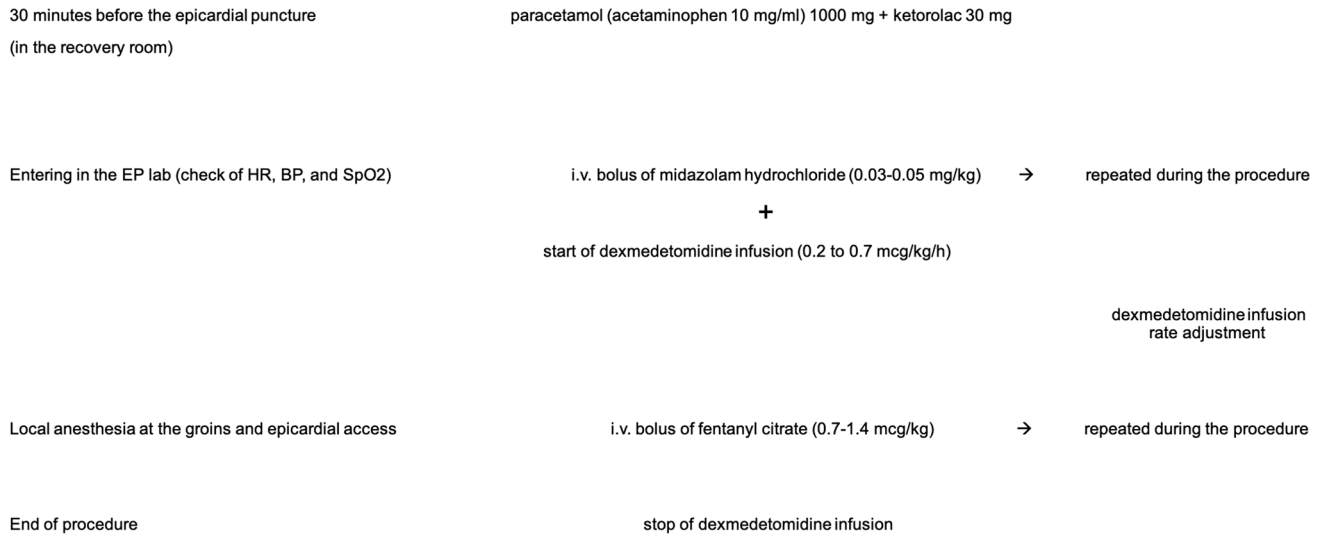|		
30 minutes before the epicardial puncture (in the recovery room)	paracetamol (acetaminophen 10 mg/ml) 1000 mg + ketorolac 30 mg	
Entering in the EP lab (check of HR, BP, and SpO2)	i.v. bolus of midazolam hydrochloride (0.03-0.05 mg/kg) → + start of dexmedetomidine infusion (0.2 to 0.7 mcg/kg/h)	repeated during the procedure
		dexmedetomidine infusion rate adjustment
Local anesthesia at the groins and epicardial access	i.v. bolus of fentanyl citrate (0.7-1.4 mcg/kg) →	repeated during the procedure
End of procedure	stop of dexmedetomidine infusion	

Fig. 1 Flow chart of the sedation protocol

performed to minimize the pain of the epicardial access. After progressive dilation, an 8.5F steerable introducer sheath (Agilis EPI, Abbott Medical, Minneapolis, MN, USA) was used in all patients. Heparin anticoagulation was usually reversed at the epicardial puncture if the epicardial access was made following systemic heparinization. At the end of the ablation, the epicardial sheath was exchanged with a pigtail, and 160 mg of triamcinolone acetonide was pushed into the epicardial space. A transthoracic echo was performed after 6 h in ICU, and the pigtail was removed in all patients. Briefly, mapping and ablation were performed using a 3-dimensional electroanatomical mapping system (CARTO 3, Biosense Webster, Diamond Bar, CA, USA, or EnSite NavX/EnSite Precision, Abbott Medical, Minneapolis, MN, USA). A quadripolar catheter was placed into the right ventricular apex. A decapolar catheter was placed into the coronary sinus as a reference point for the NavX Precision system. The coronary sinus catheter has not been used since our lab has been upgraded with the Ensite X. Epicardial mapping was carried out using the ablation catheter or a diagnostic catheter (DecaNav, PentaRay, Biosense Webster, Diamond Bar, CA, USA; LiveWire 2–2-2 mm, Advisor HD Grid, Abbott Medical, Minneapolis, MN, USA). Epicardial RF ablation was performed with open irrigated tip catheters with or without contact force sensing (ThermoCool SmartTouch, ThermoCool SF, ThermoCool ST SF, Biosense Webster, Diamond Bar, CA, USA; FlexAbility, Abbott Medical, Minneapolis, MN, USA). During mapping, the irrigation flow rate was 2 ml/min. During ablation, the power ranged from 40 to 60 W,

Fig. 2 Panel **A** is a right anterior oblique (RAO) view. Panel **B** is a left anterior oblique (LAO) view: the contrast through the Thuoy needle demonstrates the silhouette of the pericardial space. The guidewire is advanced into the pericardial space and the course of the wire is confirmed in RAO and LAO
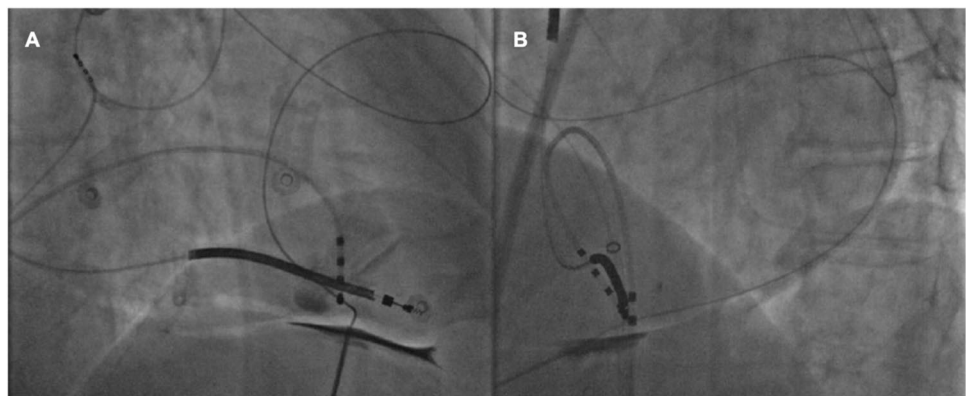
and an irrigation flow ranged from 17 to 30 ml/min. The pericardial sheath was connected to a vacuum system to drain the intrapericardial fluid continuously. All patients remained in the ICU for at least 24 h with continuous ECG monitoring or longer, depending on the patient's clinical course.

2.3 Statistical analysis

This was an observational, prospective, single-center study. Patients' clinical characteristics are reported as descriptive statistics. Continuous variables with normal distribution are reported as mean±standard deviation. Categorical variables are expressed as a percentage. All statistical tests were performed using SPSS for Windows 25.0 (SPSS, Chicago, IL, USA).

3 Results

The patient's characteristics are reported in Table 1. Sixty-nine patients with drug-refractory recurrent VT or VT storm underwent successful epicardial access and catheter ablation under conscious sedation and were included in the analysis. Two patients experienced intractable pain during catheter manipulation in the epicardial space under conscious sedation, and the procedure was switched to GA. The mean age was 65.4 ± 12.1 years; forty-six patients were males (66.6%). Forty-seven patients (68.1%) had non-ischemic cardiomyopathy (NICM), 13 patients (18.9%) had ischemic-cardiomyopathy (ICM), and 9 patients (13%) had myocarditis. Standard percutaneous sub-xiphoid access was attempted in all patients. Non-inducibility of any VT was achieved in 82.6% (9/9 myocarditis, 10/13 ICM, 38/47 NICM, $n=57/69$ patients), inducibility of non-clinical VT in 13% (3/13 ICM, 6/47 NICM, $n=9/69$ patients), and failure in 4.3% (3/47 NICM, $n=3/69$ patients).

Procedural data are reported in Table 2. The mean procedural duration, including endocardial mapping and ablation, was 213.3 ± 76.3 min. Ninety-seven VTs were induced and mapped (52/69 patients were inducible, 75.3%). Mean radiofrequency time, considering endocardial and epicardial ablation, was 33.1 ± 18.6 min, and epicardial-only mean radiofrequency time was 8.4 ± 9.1 min. Epicardial ablation was performed in 88.4% of patients ($n=61/69$). Mean HR and BP at baseline were 71.3 ± 9.4 bpm and 131.6 ± 22.8 mmHg; mean HR and BP during the ablation under conscious sedation were 62.4 ± 6.7 bpm and 106.3 ± 15.3 mmHg. The mean dose of midazolam was 3.7 ± 2.9 mg, the mean dose of fentanyl was 1.8 ± 0.6 mcg/kg, and mean dose of dexmedetomidine was 0.38 ± 0.16 mcg/kg/h.

The mean ICU stay was 1.5 ± 0.9 days, and mean overall hospital stay was 4.7 ± 2.8 days. Procedural-related complications occurred in 7.2% of patients, none related to the conscious sedation protocol. No respiratory failure, severe

Table 1 Patient's characteristics

Patient	$n=69$
Age, mean±SD	65.4 ± 12.1
Male, n (%)	46 (66.6%)
BMI, mean±SD	29.4 ± 8.5
Hypertension, n (%)	45 (65.2%)
Diabetes, n (%)	26 (37.6%)
Hypercholesterolemia, n (%)	31 (44.9%)
COPD, n (%)	9 (13%)
Renal failure, n (%)	12 (17.3%)
ICM, n (%)	13 (18.9%)
NICM, n (%)	47 (68.1%)
Myocarditis, n (%)	9 (13%)
LVEF, mean±SD	32.1 ± 14.1
CHF, n (%)	20 (28.9%)
NYHA class, mean±SD	2.4 ± 1.1
ICD, n (%)	42 (60.9%)
S-ICD, n (%)	8 (11.6%)
CRT-D, n (%)	19 (27.5%)
Arrhythmic storm, n (%)	24 (34.7%)

Legend: *BMI*, body mass index; *COPD*, chronic obstructive pulmonary disease; *ICM*, ischemic cardiomyopathy; *NICM*, non-ischemic cardiomyopathy; *LVEF*, left ventricula ejection fraction; *CHF*, chronic heart failure; *NYHA*, New York Heart Association; *ICD*, implantable cardioverter defibrillator; *S-ICD*, subcutaneous implantable cardioverter defibrillator; *CRT-D*, cardiac resynchronization therapy–defibrillator

Table 2 Procedural data

Procedural data	
Mean procedure duration, min±SD	213.3 ± 76.3
Mean RF time, min±SD	33.1 ± 18.6
Mean baseline HR, b/m±SD	71.3 ± 9.4
Mean sedation HR, b/m±SD	62.4 ± 6.7
Mean baseline invasive systolic BP, mmHg±SD	131.6 ± 22.8
Mean sedation invasive systolic BP, mmHg±SD	106.3 ± 15.3
Mean midazolam dose, mg±SD	3.7 ± 2.9
Mean fentanyl dose, mcg/kg±SD	1.8 ± 0.6
Mean dexmedetomidine dose, mcg/kg/h±SD	0.38 ± 0.16

Legend: *RF*, radiofrequency; *HR*, heart rate; *BP*, blood pressure

hypotension, or bradycardia requiring treatment has been observed among the patients. One patient experienced a transient left PN injury, which resolved within 1 week. Despite triamcinolone acetonide injection in the pericardial space, two patients experienced pericarditis and were treated with ibuprofen and colchicine. No adjunctive corticosteroid therapy was needed. Two patients experienced vascular complications, and one required surgical correction of a right femoral artery pseudoaneurysm. There were no other major

complications such as intrapericardial and/or intrathoracic bleeding, cardiac tamponade, coronary artery injuries, or acute respiratory failure.

4 Discussion

Epicardial VT ablation is usually performed only by experienced operators and in selected centers with cardiac surgery backup and anesthesiology facilities. Although we recognize that epicardial VT ablation is mainly performed under GA, a critical factor in choosing conscious sedation over GA is access to anesthesia support for these procedures. In addition to the limited anesthesia coverage, few anesthesiologists have extensive experience with these complex procedures. In our center, anesthesia coverage is limited for electrophysiology cases, which might significantly limit planning complex procedures, such as epicardial VT ablation. Given the high load of electrophysiology procedures and the limited anesthesia coverage at our center, we have evaluated different options for anesthetic management. Previous reports of anesthetic management of epicardial VT ablation describe two approaches: (a) conscious sedation using benzodiazepines plus fentanyl [17–22]; (b) GA [23]. GA may provide comfort and stability in patients with poor ventricular function and/or incessant arrhythmia requiring inotropic or mechanical support to tolerate the procedure. On the other hand, GA may worsen the hypotension associated with arrhythmia induction and also carries the potential to suppress VT induction [24–26]. GA is a variable that was also found to be associated with an increased risk of acute hemodynamic decompensation, and it is among the variable included in the PAINESD risk score [27]. Finally, an additional issue related to GA is the use of muscular relaxant agents that interfere with the ability to capture the PN with pacing [17].

To the best of our knowledge, the present study reports for the first time the use of continuous dexmedetomidine infusion in addition to midazolam and fentanyl to manage epicardial VT ablation under conscious sedation. Dexmedetomidine is a selective central α_2-agonist sedative agent with analgesic, sedative, and anxiolytic effects increasingly used for sedation and delirium treatment from sleep deprivation in ICU [6]. It has been shown that dexmedetomidine is a safe and effective sedative agent in patients undergoing cardiac surgery with minimal ventilation impairment, well maintenance of arousability [7–9], and without proarrhythmic or negative inotropic effects [10–12]. In addition, dexmedetomidine has been shown to provide deeper sedation, less respiratory depression, and better analgesia during catheter ablation of atrial fibrillation compared to midazolam plus remifentanil [19]. We did not use a higher infusion rate of dexmedetomidine as previous studies have reported the need for perioperative hypotension and/or bradycardia treatment [28, 29].

One of the recognized complications of epicardial VT ablation is the PN lesion and consequent diaphragmatic paralysis, particularly when the VT substrate is located at the base of the left ventricle adjacent to the mitral valve annulus. In these cases, to avoid PN palsy, it is crucial to identify the proximity of the left PN to the VT substrate by pace mapping of the PN [30]. During GA, neuromuscular blocking agents such as rocuronium may interfere with an adequate characterization of the PN course. Okubo et al. reported the need to reverse the muscle relaxant effect provided by rocuronium with sugammadex before performing high-output pacing maneuvers to identify the course of the PN [31]. Previous experiences have been published on different sedation protocols for epicardial VT ablation. Mandel et al. first described a case in which remifentanil and midazolam were used as sedation protocol for serial endo-epicardial VT ablation procedures, non-invasive programmed stimulation, and external cardioversion. During these procedures, the patient was awake, tolerated the procedure well, and had no recall of the cardioversion or subxiphoid access [17].

Similarly, Ramoul et al. did not report sedation-related complications using sufentanil and midazolam in their large experience. This sedation strategy does not require the presence of an anesthesiologist; it shortens patient preparation time compared to GA procedures and makes it easier to plan emergency procedures [18]. Killu et al. compared procedural events, complications, and outcomes in patients undergoing epicardial VT or premature ventricular complex ablation under sedation or GA [32]. Events and complications were defined as intra- or post-procedural bloody pericardial effusion or cardiac tamponade, chronic recurrent pericarditis, phrenic nerve injury, abdominal arterial tree injury, haemothorax, pneumothorax, pleural effusion, coronary vessel injury, liver injury and abdominal injury, intraprocedural loss of epicardial access, and requirement of blood transfusion within 24 h of the procedure. The authors did not find a significant difference in events and complication rates between the two groups.

5 Study limitations

We acknowledge some limitations of our study. This was a single-center, non-randomized study with a limited number of patients. We did not compare this protocol with other widely used protocols for sedation during catheter ablation. Although we did not observe any specific sedation-related complications, since the study's main purpose was to assess the feasibility of dexmedetomidine infusion during epicardial ablation of VT, it prevents us from deriving a definitive conclusion regarding the safety of this protocol. Furthermore, we neither did carry out a cost-effectiveness evaluation of this sedation strategy. Randomized controlled trials are needed to confirm

the safety and reproducibility of our approach. For the time being, although we recognize the advantages of performing epicardial VT ablation under GA, we acknowledge that conscious sedation using dexmedetomidine could be adopted as an alternative sedation strategy in epicardial catheter ablation of VT, particularly when anesthesia support is unavailable.

6 Conclusion

Prompt availability of anesthesiology support remains crucial for a complex procedure such as epicardial VT ablation, particularly in patients with severely reduced cardiac function. When GA is not available or not desired, continuous dexmedetomidine infusion on top of midazolam and fentanyl seems to be a feasible and safe sedation protocol in patients undergoing epicardial VT ablation.

Declarations

Ethics approval and consent to participate The study was approved by the Institutional Review Board and all patients signed informed consent.

Conflict of interest The authors declare no competing interests.

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