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RESEARCH ARTICLE

ANESTHESIA DURING ATRIAL FIBRILLATION ABLATION: FIRST EXPERIENCE AND LITERATURE REVIEW

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Abstract

Background: General anesthesia is mostly performed for radiofrequency ablation for atrial fibrillation. Deep sedation is required for cryoablation. The ideal anesthetic protocol is unknown. We sought to report our anesthetic protocol used for the anesthesia of atrial fibrillation (AF) ablations as the first experience of our University Hospital over one year, with a literature review on anesthetic considerations to accompany AF ablations.

Methods : anesthetic procedure begins with ergonomic layout of the cathlab. All patients who underwent AF ablation between January 2023 and January 2024 were identified prospectively in the cohort study. Our anesthetic protocol consists of midazolam and propofol as hypnotic agents and fentanyl for analgesia. Rocuronium is provided for general anesthesia. Intubation is required for general anesthesia. Patient is extubated once meeting standard criteria. Procedural complications are collected.

Results: A total of 24 patients underwent AF ablation from January 2023 to January 2024. The average age was 60 years, with 62% women and 38% men (paroxysmal AF 51%, CHADS2VASC 1.17). The total duration of the procedures was between 2 and 2,5 hours. The median time to extubation was 25 minutes once the procedure was completed, with a total anesthesia time averaging 140 minutes. Three patients were recovered to general anesthesia. No other anesthesia-related complications were seen.

Conclusion: Our anesthetic protocol is specifically designed for AF ablation. General anesthesia was safer than sedation, with no significant difference for efficient recovery and extubation times. Other protocols can be tested to avoid intubation. It is also necessary for anesthesiologists to optimize the space of cathlabs for safe use.

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Introduction:-
Atrial fibrillation (AF) is the most common cardiac arrhythmia. Its prevalence is 1%. It increased by over 20% in some studies (1) and can exceed 60% by 2050 (2).

Risk factors include male sex, increasing age, Caucasian and Afro American ethnicity, and cardiovascular risk factors. AF increased the risk of heart failure. Demand increased for anesthesiologists in the electrophysiology lab (EPL) for anesthesia provision and procedural guidance. It is important for anesthesiologists to be familiar with techniques, anesthetic and ventilation strategies, and the anticipated postprocedural complications.

This manuscript reports the first experience of the University Hospital for the anesthesia of AF ablations over one year from 2023 to 2024. It is also a literature review of the anesthetic periprocedural management of AF ablation.

Methods:-
This is a prospective cohort based on data from the patient referred for AF ablation performed as a first experience in the Cardiology A Department, from January 2023 through January 2024. General anesthesia (GA) is chosen at the discretion of the cardiologist for radiofrequency ablation (RFA) for total immobility, and sedation for cryotherapy (CAF). The use of curares was only done for cases of RFA, thus to check the reflex of the vagus nerve during CAF (table 1).

Good lengths of circuit and monitoring cables were installed for the occasion in the EPL. A venous line is taken from the patient's left arm and connected to intravenous extensions.

Patient instrumentation is minimized with no invasive blood pressure monitoring. Communication with the heart team is essential, mainly concerning hemodynamic events where vasopressor drugs (norepinephrine) are often used.

Airway protection was done by intubation during GA, and by a facial mask during sedation or a laryngeal mask if ventilation conditions are not optimal. Recovery starts when the AF ablation is done for expediting patient extubation. Patient is extubated once meeting prerequisites.

We don’t give protamine when catheters are removed. Echocardiography was done to rule out pericardial effusion or pulmonary edema.

The patient is transferred to critical unit care to ensure that there are no cardiorespiratory or neurological complications.

All anesthesia-related parameters were collected : anesthetic technique, airway protection, total procedure time (from vascular access to removal of catheters), total anesthesia time (from intubation to extubation), time to extubation (from ablation validation to removal of endotracheal tube), amount of IV fluids infused during procedure, and complications in particular conversion to GA, reintubation, anesthesia awareness, or other complications occurring in the immediate 24 postoperative hours.

Results:-
A total of 24 patients underwent AF ablation from January 2023 to January 2024. The mean age was 60 years (CHADS2Vasc 1,17, 51% paroxysmal AF). Total procedure time was 85-150 minutes. Total anesthetic duration was between 95 and 180 minutes. The median time to extubation was 18 minutes after the procedure was completed. The procedural difference between GA and sedation is 90minutes. An average of 600 mL of fluids were given. 18% of patients were converted to GA due to agitation, with no other anesthesia-related complications seen. Other results are reported on tables 2 and 3.

Discussion:-
Pathophysiology :
AF is a disorganized electrical and mechanical atrial activity responsible for an irregular ventricular response. The sino atrial node is the heart pacemaker. In AF, atria and pulmonary veins (PVs) are the triggers for myocardial depolarization. The sinoatrial node conducts slower when receiving signals faster (1). It is protective in AF given that only a portion of the abnormal impulses (300 to 600 beats/min) reach the ventricles (90 to 170 beats/min (3)).

Therefore, the auricular volume is incompletely ejected in the ventricle. That increases the risk of thrombus formation and stroke. P waves on the electrocardiogram are replaced by trimulation of the isoelectric line with irregular R-R intervals.

Ablation techniques :
Great progress has been made in the treatment of AF. Andrade et al. (4) and Wazni (5) suggest the superiority of catheter ablation (CA) as initial therapy, while data from the EAST-AFNET 4 Trial Investigators (6) and Kim and al. (7) strongly suggest the effectiveness of antiarrhythmic drugs (2).

RFA and CAF are the two ablation techniques used to treat AF. Both use a circumferential point-by-point determination of lesions to electrically isolate the PVs ostia from the left atrium (LA), thereby liminating ectopic triggers responsible for initiating AF (1). A femoral venous sheath is used to access the LA by the right atrium, then trans-septal puncture is performed under intracardiac echocardiographic and fluoroscopic guidance.

RFA has revolutionized the treatment of drug-refractory AF. During RFA, thermal energy arises from electrical energy, causing irreversible necrosis. Infusion of saline flush “Cool flow” provides cooling on the catheter tip. Saline can be recirculated at the catheter tip if loop is closed (8). Our team uses on average 500 ml of liquid.

CAF is also used as an alternative to radiofrequency for high risk adjacent structure damage (8). During this technique, a gas of nitrous oxide is delivered into a balloon for freezing the endocardium to impair tissue conduction (1, 8).

CAF is reversible and decreases the risk for thrombus formation. It uses very low temperatures, (8). Occluding the PVs with the cryoablation balloon allows to reduce blood flow and avoid radiating heat (1).

Preoperative patient management:
It is necessary to obtain a complete cardiac and medication history and underlying risk factors for AF. A CHADS2VASC score should be calculated. Additionally, several factors of the risk of a thromboembolic event should be considered, including anticoagulation treatment, LA size, and AF duration.

An echocardiogram should be examined preoperatively, especially to rule out intracardiac thrombus. The higher the risk for stroke, the more risk of thrombus in the LA appendage (2% of patients receiving therapeutic anticoagulation have a thrombus) (1).

Many patients have anticoagulants and/or antiplatelet drugs. The EP team managed the timing of the preoperative interruption. Our team followed the same practice. Continuation or suspension of NOACs is controversial. Both of these outlooks seem reasonable for the European Heart Rhythm Association 2015 consensus (8). The American Heart Association (AHA) recommended in 2021 to stop oral anticoagulant therapy at least 24 hours before cardiac catheterization to minimize periprocedural bleeding. On the other side, holding OAC includes potential ischemic complications. Considerations based on the thrombotic risk of OAC interreption and the bleeding risk when continued should be balanced. Bridging with low-molecular-weight heparin is often recommended in patients at high risk of thrombotic complications (mechanical valves, stroke) (9).

Intraoperative management:
Ergonomics and risk management:
The anesthesiologist’s needs in EPL are not sought before constructing the lab. The workspace is also small and non-ergonomic, such as the limited electrical outlets available (11). Heavy gadgets can hurt anesthesiologists if unexpected movement of the C-arm of the machine occurs (10).

Furthermore, there are nonorms alloted for the anesthesia workstation. Access to the patient is limited by the fluoroscopy device (10).

Hence, one has to know EPL and should be able to manage airway or hemodynamic incidents if they occur.
Long enough monitoring cables and intravenous extensions with good length of respiratory circuit are necessary to avoid accidental disconnection (10) and stay away from fluoroscopy.

During an emergency, the anesthesiologist ensures securing the airway, stabilizing hemodynamics, cardiopulmonary resuscitation, cardioversion, and defibrillation. Anesthesia workstation should be kept ready to manage situations at risk (tamponade or unstable arrhythmia (8)) when required, by checking all emergency and anesthetic drugs with airway instruments and a defibrillator (10). Our anesthesia team followed the same procedures to make their gesture safer.

Standard American Society of Anesthesiology monitors are sufficient. It includes a 5-lead electrocardiogram, a pulse oximeter, a noninvasive blood pressure cuf, and end-tidal carbon dioxide measuring. Large-bore (16 gauge or larger) intravenous access is necessary. Intra-arterial catheters are inserts for high cardiovascular risk factors (e.g., very low ejection fraction or malignant arrhythmias) (5) and may allow multiple blood samples (1, 8, 13). Only standard monitoring was used to all our patients.

Transesophagial echogardiogram (TEE) and transthoracic echogardiogram (TTE) are useful to assist trans-septal puncture and to diagnose pericardial effusions. For this reason, TEE and TTE was performed for all our patients. Echogardiogram can also shorten total procedure times (8).

Radiation exposure safety:
Anesthesiologist and assistant should wear at least a lead apron, even if heavy end tiring (8), and a thyroid shield to avoid eradiation. Many effects can occur, such as cellular mutation and cancer, infertility, and birth defects (12).

A dosimeter is handed over to anesthesiologist for cumulative exposure tracing as recommended by the International Commission on Radiation Protection. There is no safe lower limit of exposure (12) but the maximum recommended exposure to radiation is 5 rems/year (10).

Anesthesiologist should apply these principles (12): maximize distance (at 80 cm (10)) from the fluoroscopy device, limit the exposure time, and use radiation protection. It can reduce the cattered dose to approximately a quarter of the original dose (10).

Interteam communication:
This is an important point te raise because team members (cardiologists, anesthesiologists, and nurses) may be unfamiliar with the procedures. Planned events are discussed in a pre-procedure briefing. It includes positioning, induction of anesthesia, specific requirements, and post-procedure recovery from anesthesia.

General anesthesia or sedation:
AF ablation procedures have doubled over the last few years, and general anesthesia remains most commonly used (14).

AF ablation can be a lengthy procedure, leading to many anesthesia challenges for both the electrophysiologist and the anaesthesiologist. Furthermore, the ideal GA or sedation protocol is unknown (15). Both sedation and GA have their own advantages and disadvantages (1, 16).

The choice of anesthetic technique is often institutional, and the two methods can be effective, in terms of ablation time and success of AF ablation at 1 year (17). Deep sedation and GA allow for both patient and electrophysiologist comfort and reduce or abolish the patient's pain, especially when radiofrequency is used (14). But GA can even be superior in terms of reducing the incidence of PVs reconnection when compared with deep sedation (1). Whereas patients with sedation had less anesthesia and recovery time (31% shorter median case duration (17,18)) and procedure cost than GA (17), with fewer side effects on the hemodynamic stability. In our study, sedation reduces anesthesia time by half. GA was considerably longer than sedation by 90 min.

on the other hand, sedation is not suitable for long and painful cases like RF. Agitation is synonymous with arrhythmia remapping and increases procedural duration. GA can avoid this type of complication (16). This is a situation that we encountered for the first cases, where 18% of cases were converted to GA.

In a retrospective study done between 2013 and 2018 on 54321 adult patients who underwent AF ablation, general anesthesia was the most commonly used technic (18).

In another study, the proportion of procedures performed under deep sedation (22.7–27.5%; P< 0.01) increased, whereas the use of conscious sedation decreased (41.2–32.0%; P< 0.001) (14). In our study GA was used in 68% of our cases Vs 38% of deep sedation.

Maintenance of a depth of sedation sufficient to prevent movement may be challenging and require assistance in maintaining a patent airway. Midazolam, fentanyl, and propofol can be used to sedate patients without requiring endotracheal intubation (1,8). But deep sedation may result in hypoxemia, hypercarbia, or airway compromise, particularly in obese patients or those with obstructive sleep apnea (OSA) (1). It's important to dispense oxygen by face mask as needed to keep oxygen saturation within normal limits. In a Mayo Clinic study of 208 EP ablations under sedation, 40% required an airway device and 10% converted to GA (8).

Anesthetic drugs:

Hypnotic drugs such as propofol and midazolam were commonly used, whereas opioids like remifentanyl and fentanyl were the most commonly used (14). Other sedative agents can minimize respiratory changes when used (ketamine or dexmedetomidine) (19, 20). Dexmedetomidine can, as demonstrated, suppress supraventricular arrhythmia safter congenital heart surgery (21) and ketamine is a proarrhythmic agent and can increase significantly heart rate when used for deep sedation. Ketamine may be beneficial for patients with bradycardia and hypotension (8). Droperidol can depress accessory pathway conduction, and opioids and barbiturates can be safe in WPW syndrome (22). Volatile anesthetics halothane, isoflurane, and enflurane can lead to a slowdown in AV conduction (23). Clinically, sevoflurane appears to be safer for atrioventricular (AV) nodes and accessory pathways (8).

For portions of certain procedures, the electrophysiologist may request that sedation be minimized so that arrhythmias can be more readily elicited for the diagnostic portions of the procedure.

In other situations, to obtain the effective level of the depth of sedation, drugs may exacerbate hemodynamic instability in addition to inconvenient access to the patient and infusion pumps during imaging. Sometimes, supporting blood pressure with a vasopressor (e.g., phenylephrine) to maintain anesthesia deeper is necessary (1). In our study, we used norepinephrine as hemodynamic support in 90% of our patients, given their high CHADS2VASC and unavailability of monitoring of the depth of anesthesia.

We have to highlight that preoperative antibiotics are not needed for catheter ablation procedures.

Ventilation mode:

Deep sedation with noninvasive positive-pressure ventilation via continuous or bilevel positive airway pressure can protect the airway with risk of gastric insufflation (8).

GA with intermittent positive pressure ventilation decreases atelectasis. Adjusting the inspiratory-to-expiratory (I:E) ratio to 1:4 and the respiratory rate to 8 breaths/min facilitates also the mapping (15). During ablation, it has been shown that limiting the tidal volume to 250-350 ml to minimize motion with positive end expiratory pressure (typically 7 cm H_2O) to avoid atelectasis and changing rate ventilation to 12 breaths/min improve outcomes. Since lower tidal volumes may lead to, is used. Operators can request controlled apnea intervals to improve catheter stability (15). In our experience, no ventilation parameters were changed.

Another alternative showed that instead of low respiratory frequency, a high-frequency (30 to 40 breaths/minute) with an I:E ratio of 1:1, may provide more ablation site stability. (8).

High-frequency jet ventilation (HFJV) may improve the precision in ablation procedures without hypoxia, hypercarbia, and atelectasis of apneic maneuvers, but carries the potential risk of pneumothorax, pneumo-mediastinum, and inadequate ventilation. Minor complications were reported with an incidence of 6.9%, including atelectasis, fever, vascular congestion, and respiratory acidosis (8). Total intravenous anesthesia should be used for this technique (24).

Perprocedural anticoagulation:

It is necessary to anticoagulate during AF ablation. Thrombi can form with a systemic risk of embolization because of the trans-septal passage of the catheter from the right atrium into the LA (1) with an incidence of 10% (8). Stroke can occur during CA with an approximate rate of 0.4 to 1% (1). It's recommended to involve a heparin bolus of 100

U/kg, 120 to 130 U/kg for patients under dabigatran, rivaroxaban, and apixaban (8) before or immediately after transseptal passage (1, 8). The transseptal sheath will be retired once the catheter is positioned. Protamine is not necessary (1, 8). The decision of protamine infusion is based on the presence of postprocedural bleeding with a full reversal dose if tamponade arised. It's more challenging to manage in patients on NOACs. Prothrombin complex concentrates can beat temptation in the setting of rivaroxaban and apixaban, but its effect is controversial. Andexanet alfa, a potential factor Xa inhibitor antidote, is not commercially available and is still used in clinical trials to reverse NOACS (8).

Post anesthesia management:

Recovery

Recovery can be in the post-anesthesia care unit (PACU), interventional suite recovery area, or an intensive care unit. All our patients passed through the Intensive Care Unit.

Ideally, an attached PACU is suitable to be near EPL to avoid risk for heavily sedated or critically ill patients. If GA was performed, an attempt to extubate the patient should be made at the conclusion of the case (1).

After ablation, the atria can bestunned. Consequently, anticoagulation should be resumed without increasing bleeding risk (15). There are no guidelines for anticoagulation management after ablation. If hemostasis is achieved, warfarin can be started 4 to 6 hours after, and NOACs (dabigatran and rivaroxaban) can also be safely restarted 3 hours after CA (8). All our patients received their anticoagulation the evening of the ablation procedure after consulting the cardiac team.

Complications :

Bleeding :

Cardiac tamponade:

Cardiac tamponade can occur in approximately 1.3% of CA of AF and is considered the first cause of death (1). Multifactorial causes are described, it includes transseptal passage, catheter manipulation, and systemic anticoagulation. It is necessary when hemodynamic instability occurs to confirm diagnosis by echocardiography. Pericardiocentesis equipment also should be available at all times. Initial treatment is supportive by using vasopressors and fluids. Reversal of anticoagulation with the presence of catheters within the heart can be discussed (1, 8). A pericardial drain may be necessary for large pericardial effusion. Surgical treatment may be needed if the bleeding is uncontrolled.

Retroperitoneal hemorrhage:

Rarely, retroperitoneal hemorrhage occurs following femoral or iliac artery trauma. It can occur in only 0.07% of patients (1). We fear his presence when hypovolemia lasts despite a negative echocardiogram. Treatment requires administration of blood and possibly surgical repair.

Arrhythmias :

Arrhythmias can occur while manipulating the heart with sudden changes in arterial blood pressure.

Thermal injury :

•**Risks of RFA:**

Esophageal thermal injury (which can also occur with cryoablation) is monitored with an esophageal temperature probe positioned closely to the ablation catheter (1). Contrariwise, esophageal temperature probes can lead to esophageal lesions (25).

Esophageal ulcer is the more common complication, with up to 12% of cases. It is generally managed conservatively without surgical intervention (1). Atrial-esophageal fistula is the most dangerous thermal injury with an incidence rate of 0.2%, with risk of air emboli and sepsis and a high mortality rate. It can be managed by surgery or the placement of an esophageal stent.

•Risk of CAF:

Phrenic nerve injury (which can also occur with radiofrequency ablation) typically occurs in 4.4 to 7.5% of cases of cryoablation procedures, because smaller balloons are placed more distally into the PV, close to the phrenic nerve. To prevent phrenic nerve injury, monitoring of phrenic stimulation must be considered. The peak in the ECG is simultaneous with stimulation of the phrenic nerve. Alterations in the ETCO2 curve are concomitant with the diaphragmatic contraction that occurs with stimulation of the phrenic nerve. The right phrenic nerve is paced by a catheter near the right-sided PVs. Necessarily, we must avoid neuromuscular blockade drugs (or the use of anticholinesterase inhibitors to reverse existing blockades) (1). Manual (hiccups) and fluoroscopic monitoring of diaphragmatic motion is performed; ablation is stopped temporarily immediately if the motion slows or ceases.

Stroke :
Stroke may occur because of air embolism introduced into the trans-septal sheath or an atrio-esophageal fistula. Treatment is mostly supportive by putting the patient in trendelenburg and introducing vasoactive agents, pacing the heart if conduction blocks occur, and oxygenothrapy. Sometimes hyperbaric oxygen therapy, combined with aggressive resuscitative efforts is necessary (1).

Fluid overload:
Open irrigation in RFA is associated with a volume load of 17 to 30 mL/minute. Prophylactic administration of diuretics (20 to 40 mg of IV furosemide) (8) can prevent pulmonary edema (1).

Pulmonary Hemorrhage:
PVs stenosis after ablation or traumatic catheter manipulation can lead to hemoptysis and pulmonary hypertension (8).

Limitations:
The main limitation is the size of our study population, which remains modest compared to large European and American centers. The lack of a comparison group with another anesthetic protocol is another limit to this study.

Table Legends:
Table 1:- Anesthesia protocol of GA and sedation.

GENERAL ANESTHESIA	SEDATION
INDUCTION : midazolam (1-5 mg) and rocuronium (1-1.5 mg/kg or 50 mg), propofol titration (1-2 mg/kg titrated to effect; usual total induction dose of 100-200 mg), fentanyl (25-30 mcg IV, usual dose 250 µ),	INDUCTION : midazolam (1-3 mg) and propofol titration (100-150 mg) fentanyl (150 µ) with particular attention to effectiveness anesthesia by a Ramsay score of 5
ANESTHESIA MAINTENANCE : infusion of rocuronium (0.02-0.06 mg/kg/min) additional boluses of propofol (20-40 mg) given as needed. Repeat boluses of fentanyl (25-50 µ) are used as needed. Isoflurane can be used according to hemodynamic status.	ANESTHESIA MAINTENANCE : Additional boluses of propofol (20-40 mg) given as needed. Repeat boluses of fentanyl (25-50 µ) are used as needed. Isoflurane can be used according to hemodynamic status.
After ablation, propofol is gradually decreased and ventilation set to SIMV 8 breaths/min to promote spontaneous breathing, and then switched to pressure support and propofol stopped.	

Table 2:- Patient Data.

Sexe (F)	62%
Age	60
Paroxysmal AF	51%
Flutter	49%
IMC	25.97
Hypertension	45%
Diabetis	20%
CHADS2VASC	1,17
GA	68%
Sedation	32%

Table 3:- Procedural data.

Total GA time	180 min +/- 15min
Total Sedation time	95 min +/- 18min
Time to extubate after GA	25min +/- 10min
Time to extubate after sedation	10min +/-8min

Conclusion:-

Anesthesiologists are becoming integral members of the EPL teams. Important priority should be given as well as standard guidelines for recommendation of infrastructure of EPL, and anesthesiologists need to embrace this subspecialty given their requirements for sedation, ventilation, and hemodynamic monitoring.

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Competinginterest –

No Competinginterests.

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Authors' contributions –

WA has a major contributor in writing the manuscript, AE contribute in collecting patient data. AB supervised the research. All authors approved the final manuscript

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