Medical Science and Discovery
ISSN: 2148-6832

Anesthesia Approaches in the Interventional Radiology Unit: A Retrospective Single-Center Study

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ABSTRACT

Objective: This study aimed to examine the anesthesia management in patients who underwent radiological intervention in the interventional radiology unit.

Materials and Methods: 536 patients who underwent intervention in the interventional radiology unit between 2015-2021 were evaluated retrospectively. Demographic data, American Society of Anesthesiology classification, diagnoses, interventional procedure, anesthesia method, anesthesia and interventional procedure times, anesthetic agents, intraoperative complications and postoperative hospitalization areas were recorded.

Results: Of 536 patients with a mean age of 60.06±18.19, 4.3% were <18 years old, and 53.4% were male. 397 (74.1%) patients were admitted under emergency conditions, and ASA III (54.5%) was most commonly admitted. The most common intervention was thrombectomy (66%). General anesthesia (GA) (63.6%) was the most preferred anesthesia method in interventions, sedoanalgesia at 34.1% and monitored anesthesia care at 2.3%. Propofol was the most frequently preferred iv anesthetic in GA induction (79.5%), and sevoflurane, one of the inhaled agents, was used at a rate of 81.2%. The intubation exit rate of cases was 46.4%. The intensive care unit and postoperative care unit exit rate was 89.9% (n=482). The most common complication was hypotension (15.3%).

Conclusion: The most appropriate anesthesia method should be selected for the patient's general condition, and the interventional procedure to improve the treatment results of patients,

Keywords: General anesthesia, sedation, interventional radiology, endovascular procedure

INTRODUCTION

The role of interventional radiology in diagnosing and treating diseases has increased with the increasing importance of minimally invasive interventions in our country and worldwide. The process that started with Dr. Dotter's discovery of catheters for intravenous intervention procedures in 1963 progressed rapidly and enabled the development of the concept of interventional radiology in diagnosis and treatment and the radiological conduct of many interventional procedures (1).

In the interventional procedures performed under local anesthesia (LA), the radiology team primarily performs the follow-up and monitoring of the patients. As technology develops, the number and variety of interventional procedures increase, while the patients being intervened are complex, elderly or children, and the prolongation of the procedure time has necessitated multidisciplinary teamwork, including anesthesia in these areas (2). For most cases, more than local anesthesia (LA) is needed; under the supervision of the anesthesia team during the intervention, monitored anesthesia care (MAC), sedation, sedoanalgesia or general anesthesia (GA) applications are applied to the cases, selected according to the patient and the procedure applied.

Interventional radiology applications are divided into two, vascular and nonvascular. Nonvascular procedures are usually planned in elective conditions, while in vascular procedures, the patient's condition and the intervention to be performed affect how the case is taken as an emergency or elective.

Research Article

Received 22-01-2023

Accepted 05-02-2023

Available Online: 07-02-2023

Published 28-02-2023

Fasting periods, comorbidities and medications used in patients taken under emergency conditions are unknown, or patients may be left unfollowed. In cases taken under emergency conditions such as thrombectomy, patients are generally older and have comorbidities. In interventional procedures to be performed on pediatric group patients, anesthesia support is needed to increase the child's compliance, regardless of the procedure. In pediatric nonvascular procedures, sedoanalgesia is often sufficient to perform the interventional procedure. The procedure to be applied in pediatric vascular procedures determines anesthesia management. In the adult patient group, the type, duration, difficulty, patient compliance, and medical history of the interventional procedure to be applied are the factors that determine the need for anesthesia. The procedure to be applied, the length of the procedure, perioperative complications, the patient's general condition, medical history, and preoperative fasting affect the anesthesia method. Although interventional procedures are much less invasive than surgical operations, anesthetists should consider the possible risks in these areas where non-operating room anesthesia is given. For anesthesiologists to manage emergencies, their work areas should be well organized, equipment and monitoring should be complete, and there should be an experienced team (3,4).

This study aimed to retrospectively examine anesthesia management in patients who applied to the interventional radiology unit and underwent radiological intervention.

MATERIAL and METHODs

Following the approval of the study protocol by the local ethics committee (2011-KAEK-25 2021/03-16), patients who underwent emergency or elective intervention in the interventional radiology unit of our hospital between 2015 and 2021 were included in the study. The study was conducted following the principles of the Declaration of Helsinki. Medical data were analyzed retrospectively using the hospital information system and archive records. Patients who underwent anesthesia (sedoanalgesia, MAC and GA) during the interventional procedure were included in the study. Patients of all ages were included in the study. Cases processed under local anesthesia and the anesthesia teams not included were excluded from the study. Five hundred forty-seven patients were included in the study, and 11 were excluded due to a lack of medical data in the records.

In our interventional radiology unit, anesthesia is applied for neurovascular and peripheral interventions. Thrombectomy, aneurysm coil embolization, arteriovenous malformation (AVM) embolization, endovascular cerebral aneurysm treatment, and digital subtraction angiography (DSA) are among the neurovascular interventions. At the same time, carotid stenting, hydatid cyst PAIR (puncture-aspiration-injection-respiration), biopsy, abscess drainage, percutaneous ablation therapy, percutaneous transhepatic cholangiography (PTC), nephrostomy opening and embolizing agent injection are peripheral interventions performed in our hospital.

Demographic data, American Society of Anesthesiology (ASA) classification, diagnoses, clinical branches requesting the intervention, urgency of the cases, interventional procedure, anesthesia method, anesthesia and interventional procedure times, anesthetic agents, intraoperative complications, and postoperative hospitalization areas were recorded.

Anesthesia applications

In our clinic, elective cases are routinely evaluated preoperatively by the anesthesiologist at least one day before the intervention; the patients or their relatives are informed about the procedure and anesthesia method, and written consent is obtained. According to the ASA's preoperative fasting guideline, 6 hours for solid food, formula, and animal milk, and 2 hours for water is recommended for procedures requiring GA and sedation. In emergency cases, since there is no preoperative preparation, anamnesis and fasting periods are learned from the relatives of the patients just before the procedure. Emergency cases are accepted and processed as full.

Intravenous (IV) vascular access is established in all patients, and noninvasive blood pressure, heart rate, end-tidal carbon dioxide, and peripheral oxygen saturation monitoring are routinely performed. Invasive blood pressure monitoring is also applied according to the type of procedure and patient comorbidities. Demizolam, propofol, thiopental sodium, ketamine, fentanyl, remifentanyl, and rocuronium are used for GA.

In our study, a 20% increase in systolic arterial pressure from the baseline level or >150 mm Hg hypertension, a 20% decrease in systolic arterial pressure from the baseline level or <110 beats/min hypotension, a 20% decrease in heart rate from the baseline level or <40 beats/min bradycardia and a 20% increase in heart rate from baseline or >110 beats/min were defined as tachycardia. According to the ASA guideline, difficult intubation was defined as a failure in intubation and lasting longer than ten minutes despite three or more attempts.

Statistical Analysis: Statistical evaluation was done using SPSS 23.0 program. While evaluating the study's data, descriptive statistical data were stated as frequency, percentage, and quantitative data as mean and standard deviation.

RESULTs

Five hundred thirty-six patients with a mean age of 60.06±18.19 were included in the study. 4.3% of the patients were <18 years old, and 53.4% were male. The intervention was performed most frequently on ASA III (54.5%) patients. The interventional procedure was most frequently applied to patients of the neurology clinic (84.7%).397 (74.1%) patients were emergency cases. The most common intervention was thrombectomy (66%). Neurovascular interventions constituted 85.1% of interventions performed under anesthesia (**Table 1**). In peripheral interventions, the procedure time was 46.84±25.25, anesthesia time was 50.34±26.27 minutes, while in neurovascular interventions, the procedure time was 97.80±46.99 and the anesthesia time was 107.44± 47.81 minutes. While GA (63.6%) was the most frequently preferred anesthesia method in interventions, sedoanalgesia was preferred by 34.1%, and MAC was preferred by 2.3%.

Of 23 patients aged <18 years, 3 (13%) were taken under emergency conditions, while 20 (87%) were elective. Coil

http://dx.doi.org/10.36472/msd.v10i2.866

embolization was applied to 2 (8.7%), AVM embolization to 5 (21.7%), DSA to 2 (8.7%), hydatid cyst PAIR to 4 (17.4%), biopsy to 4 (17.4%), nephrostomy insertion to 2 (8.7%), embolizing agent injection to 3 (13%) and percutaneous ablation therapy to 1 (4.3%) pediatric patient. GA was applied to 7 (30.4%) patients and sedoanalgesia to 16 (69.6%) patients.

In neurovascular procedures, GA was applied to 337 (73.9%) patients, sedoanalgesia to 114 (25%) and MAC to 5 (1.1%). Sedoanalgesia (53.3%) was the most preferred anesthesia method in carotid stenting. The anesthesia methods preferred according to the interventional procedures are given in **Table 2**. Propofol was the most frequently preferred iv anesthetic for GA induction (271, 79.5%). The inhaler was used for maintaining anesthesia in all patients, and sevoflurane was the most preferred, with a usage rate of 81.2% (277 patients).. Anesthetic agents used according to anesthesia methods are given in **Table 3**.

PTC and hydatid cyst PAIR (n=3) airway safety was ensured by laryngeal mask airway, while endotracheal intubation was performed in other patients. After neurovascular intervention and carotid stenting, all patients were transferred to either the intensive care unit (ICU) or the postanesthesia care unit (PACU) for close monitoring.

In addition to carotid stenting, among peripheral interventions, one patient who underwent hydatid cyst PAIR, one biopsy, three abscess drainages, three PTCs, and one nephrostomy were followed up in the postoperative ICU. One patient who underwent thrombectomy, two who underwent coil embolization, one who underwent endovascular cerebral aneurysm treatment, one who underwent carotid stenting, and two who underwent percutaneous ablation were transferred to the PACU and monitored after being extubated.. In the postoperative period, 53.4% (n=286) of the patients were followed as extubated and 46.6% (n=250) as intubated. 61% (n=216) of thrombectomy cases, 26.2% (n=11) of coil embolizations, 39.4% (n=13) of endovascular cerebral aneurysm treatments, 33.3% (n=4) of AVM embolizations, 33.3% (n=5) of DSA cases, and 6.7% (n=1) of carotid stentings were monitored while intubated.. The intubating exit rate of neurovascular cases was 46.4% (n=249). The rate of admission to ICU and PACU was 89.9% (n=482). Fifty-four patients (10.1%) were sent to the postoperative clinic.

The most common complication during interventional procedures was hypotension (15.3%), while 9.3% hypertension and 5.0% bradycardia were observed. The distribution of complications according to interventional procedures, urgency, and anesthesia method are given in **Tables 4 and 5**.

Table 1: Demographic characteristics

				n (%)
Sex	Female			250 (46.6%)
	Male			286 (53.4%)
ASA	ASA I			29 (5.4%)
	ASA II			116 (21.6%)
	ASA III			292 (54.5%)
	ASA IV			99 (18.5%)
Clinic	Neurology			4454 (84.7%)
	Surgery			45 (8.4%)
	Pediatry			27 (5%)
	Internal medicine			4 (0.7%)
	ICU			3 (0.6%)
	Urology			3 (0.6%)
Anesthesia methods	General anesthesia			341 (63.6%)
	Sedoanalgesia			183 (34.1%)
	Monitored anesthesia care			12 (2.2%)
Interventional procedure	Thrombectomy	Emergency	354	354 (66%)
	Aneurysm coil embolization	Emergency	10	42 (7.8%)
	AVM embolization	Emergency	5	12 (2.2%)
	Endovascular cerebral aneurysm treatment	Emergency	13	33 (6.2%)
	DSA	Emergency	4	15 (2.8%)
	Carotid stenting	Emergency	0	15 (2.8%)
	Hydatid cyst PAIR	Emergency	3	16 (3%)
	PTC	Emergency	4	15 (2.8%)
	Biopsy	Emergency	0	13 (2.4%)
	Abscess drainage	Emergency	1	8 (1.5%)
	Percutaneous ablation therapy	Emergency	0	6 (1.1%)
	Embolizing agent injection	Emergency	0	4 (0.7%)
	Nephrostomy	Emergency	3	3 (0.6%)

ASA : American Society of Anesthesiology classification, AVM: arteriovenous malformation, DSA: digital subtraction angiography, PTC: percutaneous transhepatic cholangiography, ICU: intensive care unit, PAIR: puncture-Aspiration-Injection-Reaspiration

Table 2: Anesthesia methods in radiological intervention procedures

	General anesthesia	Sedoanalgesia	Monitored anesthesia care	Total
Thrombectomy	247 (69.8 %)	103 (29.1%)	4 (1.1%)	354
Coil embolization	41 (97.6%)	1 (2.4%)	-	42
Endovascular cerebral aneurysm treatment	33 (100%)	-	-	33
AVM embolization	12 (100%)	-	-	12
DSA	4 (26.7%)	10 (66.7%)	1 (6.7%)	15
Carotid stenting	1 (6.7%)	8 (53.3%)	6 (40%)	15
Hydatid cyst PAIR	2 (12.5%)	13 (81.3%)	1 (6.3%)	16
Biopsy	-	13 (100%)	-	13
Abscess drainage	-	8 (100%)	-	8
Percutaneous ablation therapy	-	6 (100%)	-	6
PTC	1 (6.7%)	14 (93.3%)	-	15
Nephrostomy	-	3 (100%)	-	3
Embolizing agent injection	-	4 (100%)	-	4
Total	341 (63.6%)	183 (34.1%)	12 (2.3%)	536

n, %, AVM: arteriovenous malformation, DSA: digital subtraction angiography, PTC: percutaneous transhepatic cholangiography, PAIR: puncture-Aspiration-Injection-Reaspiration

Table 3: Anesthetic drugs and anesthesia methods

		General anesthesia	Sedoanalgesia	Monitored anesthesia care
Propofol		271 (79.5%)	54 (29.5%)	-
Thiopental sodium		51 (14.9%)	-	-
Ketamine		16 (4.7%)	51 (27.9%)	-
Demizolam		202 (59.2%)	178 (97.3%)	-
Fentanyl		340 (99.7%)	134 (73.2%)	-
Rocuronium		338 (99.1%)	-	-
Inhaler Agent	Sevofluran	277 (81.2%)	-	-
	Desfluran	64 (18.8%)	-	-

n, %,

Table 4: Intraoperative complications in interventional procedures

	None	Hypertension	Hypotension	Difficult intubation	Bradycardia	Tachycardia	Arrhythmia
Thrombectomy	229 (64.7%)	37 (10.5%)	60 (16.9%)	3 (0.8%)	18 (5.1%)	4 (1.1%)	3 (0.8%)
Coil embolization	28 (66.7%)	6 (14.3%)	5 (11.9%)	-	1 (2.4%)	2 (4.8%)	-
Endovascular cerebral aneurysm treatment	23 (69.7%)	3 (9.1%)	7 (21.2%)	-	-	-	-
AVM embolization	8 (66.7%)	-	2 (16.7%)	-	2 (16.7%)	-	-
DSA	8 (53.3%)	-	4 (26.7%)	-	3 (20.0%)	-	-
Carotid stenting	10 (66.7%)	2 (13.3%)	-	-	3 (20.0%)	-	-
Hydatid cyst PAIR	16 (100%)	-	-	-	-	-	-
Biopsy	12 (92.3%)	-	1 (7.7%)	-	-	-	-
Abscess drainage	8 (100%)	-	-	-	-	-	-
Percutaneous ablation therapy	5 (83.3%)	1 (16.7%)	-	-	-	-	-
PTC	12 (80.0%)	-	3 (20.0%)	-	-	-	-
Nephrostomy	2 (66.7%)	1 (33.3%)	-	-	-	-	-
Embolizing agent injection	4 (100%)	-	-	-	-	-	-

n, %, AVM: arteriovenous malformation, DSA: digital subtraction angiography, PTC: percutaneous transhepatic cholangiography, PAIR: puncture-Aspiration-Injection-Reaspiration

http://dx.doi.org/10.36472/msd.v10i2.866

Table 5: Distribution of complications according to urgency and anesthesia method

	None	Hypertension	Hypotension	Difficult intubation	Bradycardia	Tachycardia	Arrhythmia
General anesthesia	217 (63.6%)	25 (7.3%)	75 (22.0%)	3 (0.9%)	15 (4.4%)	4 (1.2%)	2 (0.6%)
Sedoanalgesia	138 (75.4%)	24 (13.1%)	7 (3.8%)	-	11 (6.0%)	2 (1.1%)	1 (0.5%)
Monitored Anesthesia care	10 (83.4%)	1 (%8.3)	-	-	1 (%8.3)	-	-
Emergency procedure	260 (65.5%)	41 (10.3%)	65 (16.3%)	3 (0.8%)	20 (5.0%)	5 (1.3%)	3 (0.8%)
Planned procedure	105 (75.5%)	9 (6.5%)	17 (12.3%)	-	7 (5.0%)	1 (0.7%)	-

n, %

DISCUSSION

In interventional neuroradiology, the frequency of minimally invasive intervention treatment using the endovascular route in central nervous system diseases is increasing day by day. There is no established superiority of one anesthetic management over the other in interventional neurovascular procedures. The choice between general anesthesia or sedation is made based on the patient's condition and the type of procedure (3). While choosing the anesthesia method in neurovascular interventions, the patient's condition, pathology, lesion localization, technical characteristics of the interventional procedure, and the risks involved should be considered (5-7). In the literature, the superiority of sedation practices and GA over each other is discussed by considering many factors about the choice of anesthesia method in patients undergoing thrombectomy due to acute ischemic stroke. There are different opinions (8-10).

Sedation allows the evaluation of patients' neurological functions throughout the interventional procedure. However, being in a supine position for a long time during the procedure, contrast injection pain, and pain due to manipulation in the vascular area may cause discomfort in patients, and the desired immobility may not be achieved with sedation. Sedation should not be preferred in patients with limited cooperation who do not obey orders and in patients whose fasting duration is unknown. In sedation applications, hemodynamic problems that GA may cause can be avoided (3,11).

General anesthesia is preferred in most neurovascular cases due to the need for long-term interventions, the importance of maintaining stable hemodynamics and monitoring for complications, and the fact that immobility during the intervention improves image quality and increases the chances of a successful outcome (4). In addition, GA is preferred in patients who cannot cooperate, have a low Glasgow coma scale, and in pediatric neurovascular interventions (12). GA can cause hemodynamic instability. However, the balanced GA allows for the controlled blood pressure changes required during the intervention. Cerebral protection strategies are used to prevent secondary injury in induction and maintenance in neurovascular cases in which GA is preferred. These include providing normocapnia and avoiding hypoxia, hypertension, and hypotension (13). Conditions that may cause an increase in intracranial pressure, such as coughing and vomiting, should be prevented in patients who are extubated at the end of the procedure (4). GA provides airway protection and facilitates airway management during interventional procedures. Especially in patients whose fasting period has not been completed, the risk of aspiration increases in sedation applications. In order to ensure airway safety and prevent complications in patients whose preoperative fasting period has not been completed, patients should be evaluated well in the preoperative period, and the fasting period should be considered in the selection of the anesthesia method (2,14). In our study, GA was the most preferred anesthesia method in thrombectomy cases. Multiple factors, such as the patient's general condition, the duration of fasting, and the anesthesia preference of the radiologists, were effective in selecting the anesthesia method.

Sedation and GA are preferred methods in coil embolization applications in cerebral aneurysms. However, anesthetists and radiologists often prefer GA. As in other neuroradiological cases, GA is the first choice because of stable hemodynamics, avoidance of sudden changes in intracranial pressure, and complete immobility in the patient (15,16). Especially in critical coil embolization cases and during deployment, hemodynamic stability should be ensured, and movement of the patient should be prevented. Anesthesiologists should be careful that potential complications such as hemorrhage, thromboembolism in the distal vessels, cerebral ischemia, pulmonary embolism and vasospasm may occur during these procedures. Vasospasm is a common complication of coil embolization and, if left untreated, can lead to delayed recovery from anesthesia and, more importantly, to postoperative neurological deterioration. It is recommended that the mean arterial pressure be higher than the basal value to maintain cerebral perfusion pressure in cases with vasospasm (8-10). In the embolization of arteriovenous malformation (AVM), GA is preferred because the patient is entirely immobile during embolizing agent injection, and bradycardia and hypotension are desired. Hypotension and bradycardia are used to reduce flow from the AVM and place embolic material safely (17).

In our study, it was seen that the most preferred anesthesia method in neurovascular cases was GA.

Anesthetic agents that provide immobility, optimal cerebral perfusion pressure, cardiovascular stability, blood pressure regulation, and early awakening to evaluate the patient's neurological status should be preferred in neuroradiological interventions (8,12,18,19). Total intravenous anesthesia (TIVA) or balanced anesthesia can be used in anesthesia management in the interventional radiology unit (18,19). Propofol can cause systemic hypotension, and decrease cerebral blood flow, intracranial pressure and metabolic demand. Therefore, propofol may be preferred for induction in increased intracranial pressure or intracranial hypertension. Inhalation anesthetics induce cerebral vasodilation and increase cerebral blood flow, but in this case, it may be challenging to follow up when a neurophysiological examination is required (20,21). TIVA and inhalation anesthesia are helpful for the rapid titration of arterial pressure when voluntary short-term hypotension is needed (3). In our study, there was no neurovascular intervention using TIVA, while propofol was the most frequently preferred iv anesthetic agent in GA patients, while sevoflurane was the most commonly used inhaler.

An uneventful and rapid recovery from GA is essential for early neurologic evaluation in the postoperative period (18). Soft and early extubation is essential for early neurological examination. Extubation of the patients immediately at the end of the procedure or slowly in the intensive care unit is determined according to the patient's current condition, additional systemic diseases, the interventional procedure applied and possible complications. Due to potential complications, close hemodynamic and neurologic monitoring is required in neuroradiology cases. For this reason, patients should be transferred to areas such as the intensive care unit or PACU, where they can be followed closely in the postoperative period (22). In our study, all patients who underwent neurovascular intervention and carotid stenting were transferred to the ICU or PACU for close follow-up treatment. Immediate extubation of patients undergoing GA for endovascular treatment is important for breathing well, protecting their airways, and maintaining stable hemodynamics. It has been stated that extubation after the procedure may be an important prognostic factor (23). In our study, 46.4% of neurovascular interventions were intubated postoperatively. In 2 observational studies on endovascular thrombectomy performed under GA, it was reported that 60% and 70% of patients were not extubated at the end of the procedure (24,25). In our study, we had a rate of 61% intubated admission to the intensive care unit after endovascular thrombectomy, which was found to be compatible with the literature.

Endovascular treatment, including angioplasty and stenting, is performed in patients with symptomatic internal carotid artery stenosis (>70%) who are considered high-risk for general anesthesia and open surgery. This procedure, preferred to be performed with LA and/or conscious sedation allows the preservation of cerebral autoregulation and continuous evaluation of the neurological status. Stent placement may cause parasympathetic stimulation resulting in bradycardia and hypotension. At the same time, there is a risk of post-procedure hyperperfusion syndrome, so close arterial pressure monitoring is required after stenting (3). In our clinic, close hemodynamic follow-up with MAC is performed in cases of carotid stenting with LA. Carotid stenting is performed with conscious sedation for agitated and restless patients.

Minimally invasive procedures in the interventional radiology unit are a potential source of concern and pain for patients. Since pain is often felt in percutaneous interventions, LA is usually applied (26). Many peripherally applied procedures such as breast and kidney biopsy, PTC, hydatid cyst PAIR, abscess drainage, and stenting in carotid stenosis cannot be performed with LA alone due to periprocedural pain and anxiety. Supporting LA with sedoanalgesia increases the procedure's success and the patient's comfort (27,28). GA can also be given according to the general condition and preference of the patient and the procedure to be performed. Opioid and benzodiazepine combination is most commonly preferred for sedoanalgesia (29). Our study observed that in most cases, LA was supported by sedoanalgesia when it was insufficient. The most commonly used drugs in sedation procedures were benzodiazepines (demizolam) and opioids (fentanyl). GA was applied to only one PTC and two hydatid cist PAIR cases due to anxiety and agitation.

Limitations: Postoperative 24-hour complications of the patients and extubation times of the patients who were intubated were not recorded, and these parameters were not evaluated. Mortality and morbidity, and procedural success rates were not recorded.

CONCLUSION

A multidisciplinary approach, involving the anesthesia team, is essential for ensuring the safety and effectiveness of patient care during interventional radiological procedures and for achieving a successful outcome. The optimal anesthesia method should be chosen based on the patient's overall condition and the interventional procedure in order to enhance treatment outcomes, maintain stable hemodynamics, preserve adequate cerebral perfusion, prevent secondary harm, promote patient immobility, decrease complications, and facilitate quick recovery .

Acknowledgments: None

Conflict of interest: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. This research did not receive and a specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author Contributions: ANB, CY, AK, FA, ÜK, ŞE, TS: Conception and design of the study, Analyzed the data: **ANB**. Manuscript preparation, Revisions. All the authors have read, and confirm that they meet, ICMJE criteria for authorship.

Ethical approval: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and/or with the Helsinki Declaration of 1964 and later versions. Informed consent or substitute for it was obtained from all patients for being included in the study.

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