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Our experience in transcatheter aortic valve implantation (TAVI) from the anesthesiologist's perspective: A single-center retrospective study

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Abstract

Aim: This study aimed to review the perioperative complications, morbidity, and mortality rates of patients who underwent TAVI at our tertiary care hospital.

Materials and Methods: The data for this retrospective study including 34 patients were collected from their medical records. Demographic characteristics, preoperative scores, comorbidities, echocardiographic measurements, laboratory values, procedure times, perioperative complications, and mortality rates were recorded.

Results: The study cohort, predominantly the elderly population (mean age 77.3 years), underwent TAVI under local anesthesia and sedation. Anesthetic induction involved fentanyl, ketamine, and midazolam, with adjustments using propofol, as needed. Hypotension is the most common anesthesia-related complication. The procedure was completed under conscious sedation in all cases that were not complicated by surgery, with no instances of respiratory complications. The most frequent procedure-related complication was atrioventricular bundle branch block. The postoperative outcomes demonstrated a significant reduction in aortic valve parameters, validating the efficacy of the procedure. The 30- and 90-day mortality rates were 0%, indicating favorable short-term survival. Maintenance of hemodynamic stability through vasopressors, with noradrenaline being the preferred choice. While the overall length of hospital stay averaged six days, TAVI contributed to shorter hospitalizations due to increased procedural experience and refined anesthetic approaches. A permanent pacemaker was required in 20% of cases.

Conclusion: This analysis contributes insights into the evolving field of TAVI, emphasizing the role of experienced anesthesiologists in optimizing patient outcomes. We aimed to underscore the importance of refining anesthesia protocols, staying abreast of emerging guidelines, and developing solution algorithms for emergency scenarios, ultimately enhancing the safety and efficacy of TAVI procedures in a rapidly expanding patient population.

Introduction

Aortic stenosis is the most common primary valvular disease in developed countries and is caused by the degeneration and calcification of the aortic valves with increasing age [1]. Although symptoms such as dyspnea, exercise intolerance and angina can be managed with medical treatment, the definitive treatment for aortic stenosis is surgical valve replacement or transcatheter aortic valve implantation (TAVI). TAVI has become a common treatment option for patients considered high risk for surgery after years of modeling and trials.

Although patient selection for TAVI procedure is multifactorial and needs a multidisciplinary approach; one of the most important point to be considered is that experienced anesthesiologists who are familiar with the pathophysiology of aortic valve diseases should take part in the "heart team".

Anesthesia for TAVI may include local anesthesia, sedoanalgesia or general anesthesia; according to the needs of the patient and center familiarity. Morbidity and mortality related to the surgical procedure and anesthesia may occur after TAVI. Various studies have reported that 30-day mortality rates after TAVI may vary between 5.4% and 10.4% [2].

This study aimed to review the perioperative complications, morbidity, and mortality rates of patients undergoing TAVI at our tertiary care hospital.

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Materials and Methods

Our study was performed retrospectively by reviewing the medical records of patients who underwent TAVI for severe aortic stenosis between the years of 2020 and 2023 at the Gazi University Health Research and Application Center Anesthesiology and Reanimation Clinic with the approval of the Ethics Committee 1055 dated 05.09.2023. Demographic characteristics, comorbidities, presenting symptoms, EuroSCORE II, Society of Thoracic Surgeons (STS) scores, perioperative echocardiographic measurements, laboratory values, procedure times, anesthetic methods, perioperative complications, 30- and 90-day mortality rates were recorded. Inclusion criteria to our study were: 1. Patient age $\geq$ 18 years, 2. ASA status III-IV and 3. elective cases. Exclusion criteria were: 1. patient age <18 years, 2. emergent cases, 3. Patients that doesn't give informed consent for their data to be used in this study and 4. patients with missing data. There were no restrictions regarding the anesthesiology method in this study, all methods involving any kind of anesthesia and or analgesia were included in this study. After these criteria were applied, records of 34 patients were found eligible to be included in our study.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics 26 package program. In the descriptive statistics section, categorical variables are expressed as numbers and percentages and continuous variables are expressed as mean ± standard deviation. The conformity of continuous variables to a normal distribution was evaluated using a visual histogram and the Kolmogorov-Smirnov test. An independent t-test was used for data that fit the normal distribution. Pearson chi-square test was used in the comparison analysis for categorical variables between independent groups. A paired sample t-test was employed to evaluate the difference between preoperative and postoperative regarding laboratory findings and echocardiographic values. The results were considered statistically significant at $p<0.05$.

Results

Of the 34 patients admitted for TAVI under local anesthesia and sedation at the Gazi University Hospital between 2020 and 2023, 44% (n=15) were female and 56% (n=19) were male. The mean age was 77.3±7.5 years. The demographic characteristics and comorbidities of the patients are shown in Table 1. The mean EuroSCORE II was 10.2±13 and the mean STS score was 14.6±7.4. The most common reason for hospitalization was dyspnea in 58.8% (n=20) of patients. Significant improvements in the maximum aortic valve velocity and mean pressure gradients were observed between the preoperative and postoperative periods ($p<0.0001$, Table 2). When preoperative and postoperative laboratory values were compared, significant differences were observed between hemoglobin, BUN and INR values ($p=0.004$, $p=0.02$, $p=0$ .009, respectively, Table 3.)

Type of anesthesia was local anesthesia and conscious sedation in all patients. In 3 patients in whom the procedure was started with conscious sedation and local anesthesia, general anesthesia was initiated because sudden and profound hypotension, asystole, and subsequent cardiac arrest due to the interventional procedure.

The preferred drugs for sedation induction were as follows: fentanyl, 94.1% (n=32); ketamine, 88.2% (n=30); and midazolam, 88.2% (n=30). In 11 patients (32.4%), sedation was deepened with intravenous (IV) propofol because an appropriate level of sedation could not be reached. Sedation was achieved using combination of any two agents mentioned above in each patient. The aim of the combi-

Table 1. Demographic characteristics, morbidity and mortality scores, presenting symptoms of the patients.

Gender n (%)	
Female	15 (44.1)
Male	19 (55.9)
Age (mean±SD)	77.3±7.5
BMI (mean±SD)	26.3±3.6
EuroScore (mean±SD)	10.2±13.2
STS score (mean±SD)	
Mortality	5.8±2.3
Morbidity and mortality score	14.6±7.4
NYHA Score n (%)	
NYHA 2	13 (38.2)
NYHA 3	19 (55.9)
NYHA 4	2 (5.9)
Comorbidities n (%)	
Hypertension	32 (94.1)
Diabetes mellitus	12(35.3)
Coronary artery disease	24 (70.6)
Arrhythmia	15 (44.1)
Cerebrovascular event	6 (17.6)
Chronic kidney damage	15 (44.1)
Chronic obstructive pulmonary disease	11 (32.4)
Endocrinologic diseases other than diabetes mellitus	3 (8.8)
Smoking status	16 (47.1)
Cigarette pack years (mean±SD)	15.5±21.6
Presenting symptom n (%)	
Dyspnea	20 (58.8)
Angina	11 (32.4)
Syncope	5 (14.7)
Incidental	7 (20.6)
ASA score n (%)	
ASA 3	29 (85.3)
ASA 4	5 (14.7)
Mallampati Score n(%)	
Mallapati I	4 (11.8)
Mallampati II	25 (73.5)
Mallampati III	5 (14.7)

BMI: Body Mass Index, STS: Society of Thoracic Surgeons, NYHA: New York Heart Association, ASA :American Society of Anesthesiologists.

Table 2. Preoperative and postoperative echocardiographic findings.

Echocardiographic measurements	Preoperative period (mean±SD)	Postoperative period (mean±SD)	95% CI Lower	95% CI Upper	t	df	p
Ejection fraction	53.7±12.9	53.8±12.3	-,940	,882	-,06	33	0.9
Maximum aortic valve velocity (Vmax) (mmHg)	73.02±22.1	16.4±15.5	49,3	63,8	15,84	33	**<0.0001**
Mean Pressure Gradient (mmHg)	46.4±14.9	7.8±6.0	33,7	43,4	16,24	33	**<0.0001**
Aortic valve area (cm^2)	0.73±0.15	N/A	N/A	N/A	N/A	33	N/A

P<0.05 according to paired sample t test.

Table 3. Preoperative and postoperative laboratory findings.

Laboratory values	Preoperative period (mean±SD)	Postoperative period (mean±SD)	95% CI Lower	95% CI Upper	t	df	p
Hemoglobin(g/dL)	12.9±4.8	10.5±1.7	,8055	3,96	3,0	33	**0.004**
BUN (mg/dL)	24.9±11.7	21.5±7.8	,427	6,48	2,3	33	**0.02**
Creatinine (mg/dL)	1.0±0.2	0.97±0.28	-,03646	,10	1,0	33	0.32
GFR(mL/min/1.73m²)	64.7±16.0	66.5±15.5	-5,784	2,25	-,8	33	0.37
INR	1.12±0.27	1.18±0.24	-,11633	-,01	-2,7	33	**0.009**

BUN: Blood urea nitrogen, GFR: Glomerular filtration ratio, INR: International normalized ratio. P<0.05 according to paired sample t test.

Table 4. Peroperative complications.

Incidence of perioperative complications	n (%)
Hypotension	33 (97.1)
Hypertension	7 (20.6)
Hypoxemia	1 (2.9)
Cardiac arrest	3 (8.8)
Need for defibrillation	2 (5.9)
Need for ECMO	1 (2.9)
AV branch block	14 (41.2)
Need for permanent pacemaker implantation	7 (20.6)
Acute renal failure (according to VARC-2 criteria)[2]	3 (8.8)

ECMO: Extracorporeal membrabe oxygenation, VARC: Valve Academic Research Consortium.

nation was to potentiate amnestic and sedative effects and limit side effects. Nasal sevoflurane inhalation was used in 30 patients (88.2%), propofol infusion was used in two patients, and sevoflurane inhalation and propofol infusion were used together in two patients.

While balanced crystalloid solutions were preferred for maintenance of intravenous fluid infusion in all patients, one patient required blood transfusion due to active bleeding at the femoral artery cannula access site in the first postoperative hour.

Hemodynamic data and targeted arterial pressure values were used to determine the use of vasoactive and/or inotropic agents. Systemic blood pressure was maintained to ensure adequate coronary perfusion by avoiding tachycardia. In addition to fluid and volume resuscitation, vasopressor agents were used in 33 patients (97.1%) with hemodynamic deterioration before prosthetic valve placement and after rapid ventricular pacing, to ensure adequate coronary perfusion. The coronary perfusion pressure was maintained at a minimum of 60 mmHg. Noradrenaline, which has a limited tachycardia effect, was the first choice in all patients receiving vasopressors. The initial dose of noradrenaline was found to be 0.1 mcg/kg iv bolus. Noradrenaline infusion was started in patients in whom the in five minute vasopressor requirement was more than 0.2 mcg/kg. The infusion rate was titrated according to the mean arterial pressure ± 10% of the initial pressure. In patients with procedure-related cardiac arrest, adrenaline one mg was administered as part of advanced life support every three min until spontaneous cardiac circulation was restored.

When perioperative complications were analyzed retrospectively, the most common were hypotension and atrioventricular (AV) bundle branch block. The perioperative complications are summarized in Table 4.

The retrograde femoral route was used for TAVI in all patients, and none of the patients were switched to an alternative access site. The TAVI procedure time was 115.4±21.6 minutes. The mean length of intensive care unit and hospital stays were 3.3±3.2 and 6.06±7.5 days, respectively. Mortality rates at 30, 90, and 365 days were 0%.

Discussion

When the medical records of 34 patients who underwent TAVI between 2020 and 2023 were retrospectively analyzed, the procedure was completed with conscious sedation in all patients who did not experience acute surgical complications. None of the patients experienced respiratory complications such as hypopnea, negative pressure pulmonary edema or apnea due to sedation.

The most common anesthesia-related complication was hypotension, whereas the most common procedure-related complication was AV bundle branch block. Postoperative echocardiography showed a significant decrease in maximum aortic valve velocity and mean pressure gradient (<0.0001). The 30-, 90-, and 365-day mortality rates were 0%.

TAVI, which has become increasingly popular among both physicians and patients in recent years due to fewer post-

operative complications than open heart surgery, has increased more than five fold in the last five years when data from the United States of America have been analyzed [3]. In a meta-analysis and modeling study, aortic stenosis was diagnosed in 12.4% of the geriatric population aged ≥ 75 years, and severe aortic stenosis was found in 3.4% of these patients. The incidence of aortic stenosis also increases with age, and this rate can be as high as 9.8% in the population aged 80-89 years [4]. Approximately 16% of patients with symptomatic aortic stenosis have been treated with TAVI, and with this model, it was calculated that 5% of high-risk patients may be candidates for TAVI.

The average life expectancy in Türkiye has been reported to be 77.5 years in the latest statistics [5]. In an epidemiologic observational study of 2231 patients in Türkiye, the incidence of aortic stenosis was found to be 3.4% [6]. It is reasonable to expect that the incidence of aortic stenosis will gradually increase in Türkiye with an aging population. Increasing life expectancy, increasing incidence of aortic stenosis with an aging population and high demand for TAVI procedures will require anesthesiologists to possess detailed knowledge about this procedure.

Various approaches to TAVI have been described in the literature, including local anesthesia, sedation, and general anesthesia. When TAVI was first introduced, general anesthesia was often preferred because of the surgical comfort and limited experience of the anesthesiologists. Nowadays, a combination of conscious sedation and local anesthesia, which is also considered minimally invasive for minimally invasive surgery, is frequently used. In studies comparing sedation with general anesthesia, sedation was found to decrease the duration of intensive care unit and hospital stay without increasing the incidence of 30-day mortality or perioperative complications [7]. We also prefer conscious sedation in our clinic. The most important reasons for our preference for sedation are not to expose elderly patients to the risk of deep hypotension, positive pressure ventilation, prolonged intensive care unit stay, and increased morbidity and mortality associated with general anesthesia. In our study, intraoperative hypotension and the need for vasopressors were higher than those reported in the literature [8]. This may be due to the use of different values and percentages as limits of hypotension. In our practice, we do not allow the mean blood pressure values to decrease by more than 10% compared to the entry values owing to the fragile physiology and decreased compensation responses of the patients. In previous studies, the frequency of conversion from sedation to general anesthesia in elective conditions was up to 17% [9]. The main reason for this is the patients often experience pain and restlessness during the procedure. In our study, no conversion to general anesthesia was required under elective conditions. None of the patients developed hypoxemia, aspiration, laryngo/bronchospasm or respiratory arrest owing to sedation. We are in the belief that, anesthesiologists who are experienced and equipped to administer sedation during the procedure should be present at the procedure from the beginning to the end of the procedure.

The number of patients who needed to be switched from sedation to general anesthesia in emergency conditions was found to be three (8.8%). In these patients, the reason for switching to general anesthesia was solely procedural complications. In two patients, cardiac arrest developed due to acute obstruction of the left main coronary artery after prosthetic valve opening and in one patient, ventricular fibrillation developed after rapid ventricular pacing. The time for anesthesiologists to recognize the emergency in these cases was recorded to be less than 15 seconds; the time to start appropriate cardiopulmonary resuscitation was less than 30 seconds. Especially in the United States of America, where TAVI practitioners may also be responsible for patient sedation in order to reduce costs, switching to general anesthesia might overtake too early in elective conditions and necessary interventions may be delayed in emergency conditions. When our perioperative laboratory values were analyzed, the mean decrease in hemoglobin (Hb) decrease was 2.4 g/dL. In only one patient, the Hb drop was acute and related to the femoral cannula entry site, and blood transfusion was performed. The indications for blood transfusion in patients undergoing TAVI in our clinic are restricted to being symptomatic and/or an Hb level of <8.5 g/dL. In this way, we aim to avoid morbidity and mortality due to transfusion of blood products without jeopardizing patient safety.

There was no significant difference between the preoperative and postoperative creatinine values in the perioperative period, but three (8.8%) patients developed postoperative acute kidney injury (AKI), one of whom required extracorporeal membrane oxygenation (ECMO) after cardiac arrest. While no definite triggering factor could be identified in the other two cases, the procedure times were longer than the average procedure time (150 and 180 minutes respectively), and it was thought that AKI developed due to contrast nephropathy with possible increased contrast exposure. Unfortunately we were not able to obtain total amount of contrast dose in each patient, this data was missing. The incidence of AKI after TAVI ranges from 2% to 40% [10,11] The reason for this wide difference in the literature may be related to the postoperative day on which the renal function values of the patients were examined, and which diagnostic criteria were used for the diagnosis of acute renal failure.

In a meta-analysis by Benaicha et al., the pooled incidence of AKI was found to be 20% [12]. We are on the view that hospitalization of these patients at least one day before the procedure and ensuring appropriate intravenous hydration contributed to the 8.8% incidence in our study. None of the patients in our study required renal replacement therapy during the 30-day postoperative period.

In the present study, the frequency of postoperative permanent pacemaker implantation was 20% (n=7). Pacemaker implantation was performed within the first 72 hours in 85.7% (n=6) of these patients, and only one patient required a permanent pacemaker within the first 30 days. When the effects of sedation and general anesthesia on the need for a permanent pacemaker were investigated, contradictory results were observed. Although Mosleh et al. reported that the type of anesthesia selected did not make a significant difference on the need for permanent pacemaker [13], Dall'Ara et al. found that the rate of permanent pacemaker implantation occurred more frequently

after TAVI procedures performed under sedation [14]. The need for a permanent pacemaker is thought to be related to dilatation of the left ventricular outflow tract with various devices for prosthetic valve implantation and secondary damage to the His bundle [15]. Contrary to this hypothesis, in a study in which a single type of prosthetic valve was used, the incidence of permanent pacemaker implantation was found to be higher in sedated patients than in patients under general anesthesia [16]. This was attributed to the immobility of patients under general anesthesia and the ease of final positioning of the prosthetic valve, with fewer attempts during the dilatation and implantation phases. In our study, the mean duration of hospitalization was 6 days. In the first half of the 2010s, the average length of hospitalization ranged between 8.1 and 12.6 days [17,18], while studies conducted after the second half of the 2010s have shown that the average length of hospitalization could be reduced to two days [7]. Among the major factors contributing to the decrease in the length of hospital stay are gaining experience of cardiologists and anesthesiologists, the increase in the number of transfemoral interventions, and the fact that sedation and local anesthesia are preferred.

Conclusion

Aortic stenosis is the most common valvular pathology in developed countries. The incidence of this pathology is correlated with increasing age. In an increasingly aging and frail population, TAVI offers an alternative to surgery. In order to deal with a geriatric patient population with high perioperative morbidity and mortality during a highly hemodynamically unstable surgical procedure and to ensure patient safety, the TAVI team needs versatile anesthesiologists who are well-versed in cardiac pathophysiology and complications that may occur during the TAVI procedure and who can quickly determine anesthesia management according to patient needs and benefits. To meet this need, it is important that anesthesiologists optimize and standardize their own anesthesia management and determine solution algorithms based on emergency scenarios, in addition to following current publications and guidelines.

Ethical approval

Ethical approval was received for this study from Gazi University Clinical Research Ethics Committee (2023-1055).

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