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Published in:

Journal of cardiothoracic and vascular anesthesia

DOI:

[10.1053/j.jvca.2020.09.088](https://doi.org/10.1053/j.jvca.2020.09.088)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version

Publisher's PDF, also known as Version of record

Publication date:

2021

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Trauzeddel, R. F., Nordine, M., Balanika, M., Bence, J., Bouchez, S., Ender, J., Erb, J. M., Fassl, J., Fletcher, N., Mukherjee, C., Prabhu, M., van der Maaten, J., Wouters, P., Guarracino, F., & Treskatsch, S. (2021). Current Anesthetic Care of Patients Undergoing Transcatheter Aortic Valve Replacement in Europe: Results of an Online Survey. *Journal of cardiothoracic and vascular anesthesia*, 35(6), 1737-1746. <https://doi.org/10.1053/j.jvca.2020.09.088>

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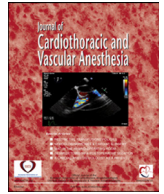
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Contents lists available at ScienceDirect

Journal of Cardiothoracic and Vascular Anesthesia

journal homepage: www.jcvaonline.com

Original Article

Current Anesthetic Care of Patients Undergoing Transcatheter Aortic Valve Replacement in Europe: Results of an Online Survey

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Objectives: Transcatheter aortic valve replacement (TAVR) has become an alternative treatment for patients with symptomatic aortic stenosis not eligible for surgical valve replacement due to a high periprocedural risk or comorbidities. However, there are several areas of debate concerning the pre-, intra- and post-procedural management. The standards and management for these topics may vary widely among different institutions and countries in Europe.

Design: Structured web-based, anonymized, voluntary survey.

Setting: Distribution of the survey via email among members of the European Association of Cardiothoracic Anaesthesiology working in European centers performing TAVR between September and December 2018.

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

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<https://doi.org/10.1053/j.jcva.2020.09.088>

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Participants: Physicians.

Measurements and Main Results: The survey consisted of 25 questions, including inquiries regarding number of TAVR procedures, technical aspects of TAVR, medical specialties present, preoperative evaluation of TAVR candidates, anesthesia regimen, as well as postoperative management. Seventy members participated in the survey. Reporting members mostly performed 151-to-300 TAVR procedures per year. In 90% of the responses, a cardiologist, cardiac surgeon, cardiothoracic anesthesiologist, and perfusionist always were available. Sixty-six percent of the members had a national curriculum for cardiothoracic anesthesia. Among 60% of responders, the decision for TAVR was made preoperatively by an interdisciplinary heart team with a cardiothoracic anesthesiologist, yet in 5 countries an anesthesiologist was not part of the decision-making. General anesthesia was employed in 40% of the responses, monitored anesthesia care in 44%, local anesthesia in 23%, and in 49% all techniques were offered to the patients. In cases of general anesthesia, endotracheal intubation almost always was performed (91%). It was stated that norepinephrine was the vasopressor of choice (63% of centers). Transesophageal echocardiography guiding, whether performed by an anesthesiologist or cardiologist, was used only $\leq 30\%$. Postprocedurally, patients were transferred to an intensive care unit by 51.43% of the respondents with a reported nurse-to-patient ratio of 1:2 or 1:3, to a post-anesthesia care unit by 27.14%, to a postoperative recovery room by 11.43%, and to a peripheral ward by 10%.

Conclusion: The results indicated that requirements and quality indicators (eg, periprocedural anesthetic management, involvement of the anesthesiologist in the heart team, etc) for TAVR procedures as published within the European guideline are largely, yet still not fully implemented in daily routine. In addition, anesthetic TAVR management also is performed heterogeneously throughout Europe.

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Key Words: TAVR; management; periprocedural; anesthesia; echocardiography

THROUGHOUT EUROPE and North America, primary aortic valve stenosis (AS) is the most common cardiac valve pathology, with an average mean survival time of 2 years in cases of symptomatic severe AS.¹ Until 2002, surgical aortic valve replacement (SAVR) was the only definite treatment for AS. Since 2002, the minimally invasive transcatheter aortic valve replacement (TAVR) technique has become an alternative treatment for symptomatic patients with severe AS not eligible for SAVR due to a high periprocedural risk or relevant comorbidities.²⁻⁴

Although clinical outcomes have improved over the past years, intra- and postoperative anesthetic TAVR management is still subject to research.^{5,6} One such area applies to whether general anesthesia (GA) or monitored anesthesia care (MAC) should be employed during TAVR. Although these 2 methods currently account for nearly half of all types of anesthesia used globally during TAVR procedures,^{7,8} MAC increasingly has been used throughout Europe and North America.⁹⁻¹³ In contrast to existing guidelines regarding the indications for a TAVR, there are no guidelines for the performance of anesthesia, whether MAC or GA, in these patients.⁹

Another area of debate concerns pre- and postprocedural management. In this context, a “heart team,” consisting of a cardiologist, cardiac surgeon, as well as a cardiac anesthesiologist, has to indicate whether SAVR or TAVR would be the best method for any given patient. Such a heart team has to be involved in the decision-making according to European and national guidelines and legislation.^{1,14} However, it is unclear if such heart teams are widespread across Europe. This includes whether an anesthesiologist is a member of a dedicated heart team in the indication and decision process, as well as periprocedural management during and after TAVR. The standards and management for these topics may vary widely among different institutions and countries.⁵

Thus, this survey was performed in order to assess the current state of perioperative anesthetic care of TAVR patients in Europe.

Methods

A structured, web-based, anonymized, voluntary survey was distributed by email among members of the European Association of Cardiothoracic Anaesthesiology (EACTA) working in European heart centers performing TAVR between September and December of 2018, which was accessible for a 4-week time frame. Multiple answers were possible.

The survey was designed by members of the subcommittee “Echocardiography” of EACTA by means of a Delphi method. The survey consisted of 25 questions. Questions 1 to 3 requested information concerning geographical information, such as country of origin and type of hospital, as well as the number of TAVR procedures performed per year at their respective institutions. Questions 4 to 6 assessed the TAVR route of approach (ie, transfemoral, transapical, etc), age, and EuroScore II of the patients undergoing TAVR procedures.

Questions 7 to 9 inquired about the medical specialties present at each facility, if the decision for TAVR was made preoperatively by an interdisciplinary heart team involving an anesthesiologist, and if a national curriculum existed for cardiothoracic anesthesia. Questions 10 and 11 examined the preoperative TAVR evaluation of the patient’s cardiovascular system, as well as anatomy of the aortic valve/root and vessels. Questions 12 to 19 dealt with the intraoperative anesthesia regimen (ie, type of anesthesia, method of securing the airway, pharmacology regimen, vasoactive medications, as well as monitoring devices used). The postoperative care was examined in Questions 20 to 22, whereas question 23 examined postoperative complication management. Questions 24 and 25 dealt with anticoagulation therapy intra- and postoperatively.

The complete questionnaire form can be found in the supplementary material.

For statistical analysis, Excel 2016 (Microsoft Corporation, Redmond, WA) and SPSS version 22 (IBM, Armonk, NY) were used. Figures were created using Prism 5.0 (GraphPad Software, San Diego, CA) and Excel 2016. Results are given as absolute numbers and percentages.

Results

A link to the survey by email was sent out to 353 society members working at TAVR centers within Europe. Seventy of them participated in this voluntary survey, resulting in a response rate of 20%. Of the 70 participants in total, 13 (19%) only partially answered the questionnaire. [Figure 1](#) shows the distribution of countries that responded. Most responders worked at university hospitals (67%), 29% at maximum supply non-university hospitals, which provide tertiary care, but are not an academic teaching hospital, and 4% at hospitals of standard care, which provide secondary care. Reporting participants mostly performed 151-300 TAVR procedures per year. However, also 10% of the responders stated that fewer than 25 TAVRs annually are implanted in their center ([Fig 2](#)). The transfemoral approach was the most often used route of access ([Fig 3](#)).

Patient Characteristics

[Figures 4 and 5](#) show the mean estimated age and EuroScore II of the patients, respectively. The vast majority of patients being treated with TAVR was between 75 and 85 years old and had a mean EuroScore II between 10% and 20%. No

patients younger than 60 years or older than 90 years underwent a TAVR according to the participants of the survey.

Qualifications and Medical Specialties Present

In more than 90%, according to the participating members, a cardiologist, cardiac surgeon, cardiothoracic anesthesiologist, and perfusionist always were available. Sixty-six percent of the responders had a national curriculum for cardiothoracic anesthesia. Among 60% of the members answering the survey, the decision for TAVR was made preoperatively by an interdisciplinary heart team including a cardiothoracic anesthesiologist. Five of the European countries surveyed (Portugal, Belgium, Poland, Finland, and Lithuania) did not answer this question in the affirmative.

Preoperative Evaluation of TAVR Patients

The frequency of routinely performed preoperative diagnostic examinations in the TAVR evaluation is displayed in [Figure 6](#). In most cases, electrocardiograms (ECG), chest X-rays, transthoracic echocardiographies, computed tomographies (CT), as well as coronary angiographies, were performed before TAVR. Candidates for TAVR underwent a preoperative CT, with a three-dimensional evaluation and analysis of the aortic valve/root and vessels, by 77% of the respondents.

Intraoperative Anesthetic Management

Ninety-one percent of anesthesiologists were present over the whole TAVR procedure. There was some variation seen

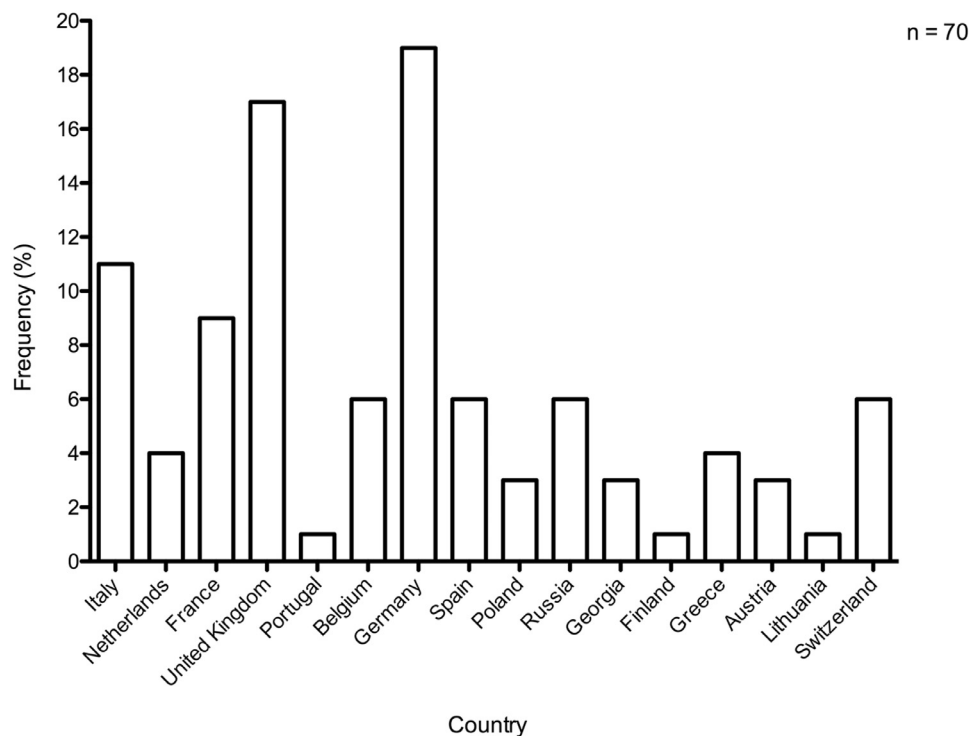


Fig 1. Distribution of countries that responded to the survey.

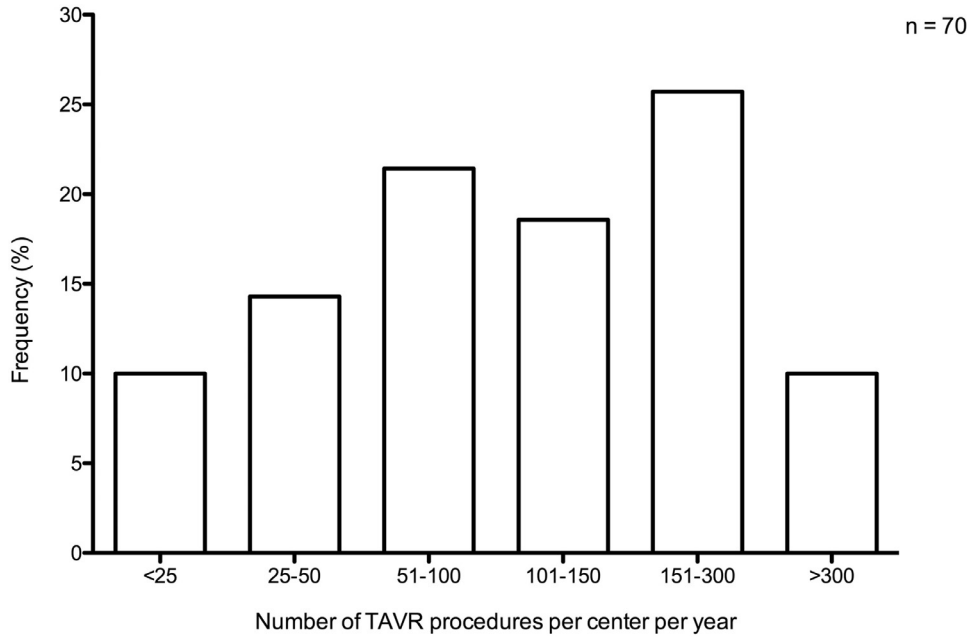


Fig 2. Distribution of the number of TAVR procedures per center per year. TAVR, transcatheter aortic valve replacement.

when broken down by country. Two (out of 4) members working in Poland and 4 (out of 8) members working in Swiss centers stated that an anesthesiologist was present. An anesthesiologist was present for TAVR in almost 70% of all responses from the Netherlands, France, and in the United Kingdom. In all other countries, anesthesiologists were present for 100% of all TAVR procedures performed. GA and MAC were employed in 40% and 44%, respectively. In 48.6% all techniques of anesthesia were offered to the patients and in 23% local anesthesia. If GA was applied, an endotracheal tube or supraglottic device was used in 91% and 9%, respectively.

Drugs used for induction and maintenance of GA, as well as (analgo-)sedation, are shown in Figures 7 and 8, respectively. Propofol, volatile agents, and remifentanyl mostly were used for GA. Interestingly, propofol and remifentanyl also were the most frequently used agents for (analgo-)sedation. Dexmedetomidine was estimated to be used in 30% of MAC.

The following monitoring devices were used intraoperatively: noninvasive arterial pressure (31%), invasive arterial pressure (91%), capnography (83%), pulse oximetry (97%), near-infrared spectroscopy (13%), processed electroencephalogram (14%), 3-lead ECG (16%), 5-lead ECG (81%), cardiac

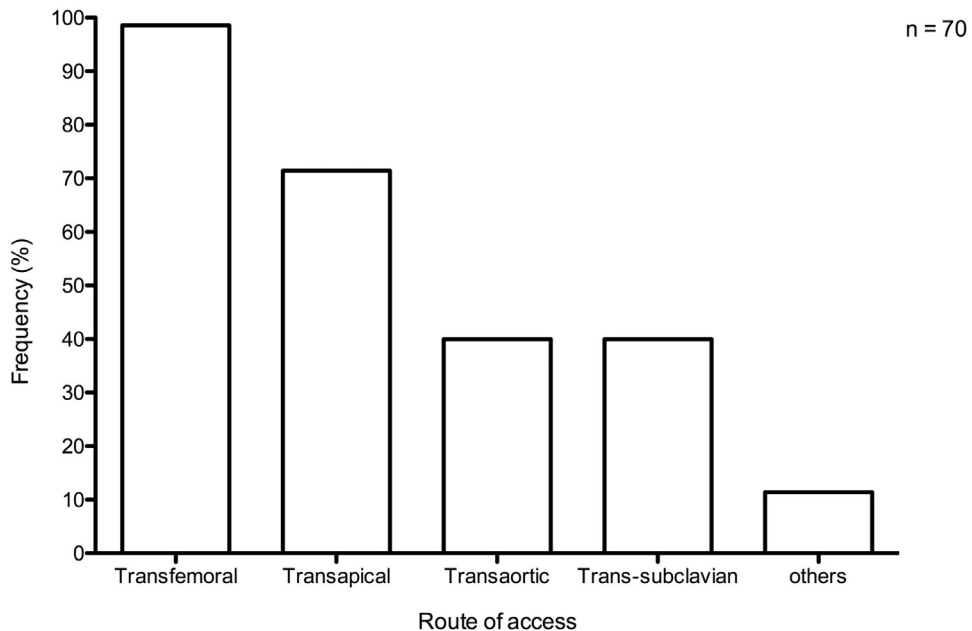


Fig 3. Distribution of access chosen for TAVR.

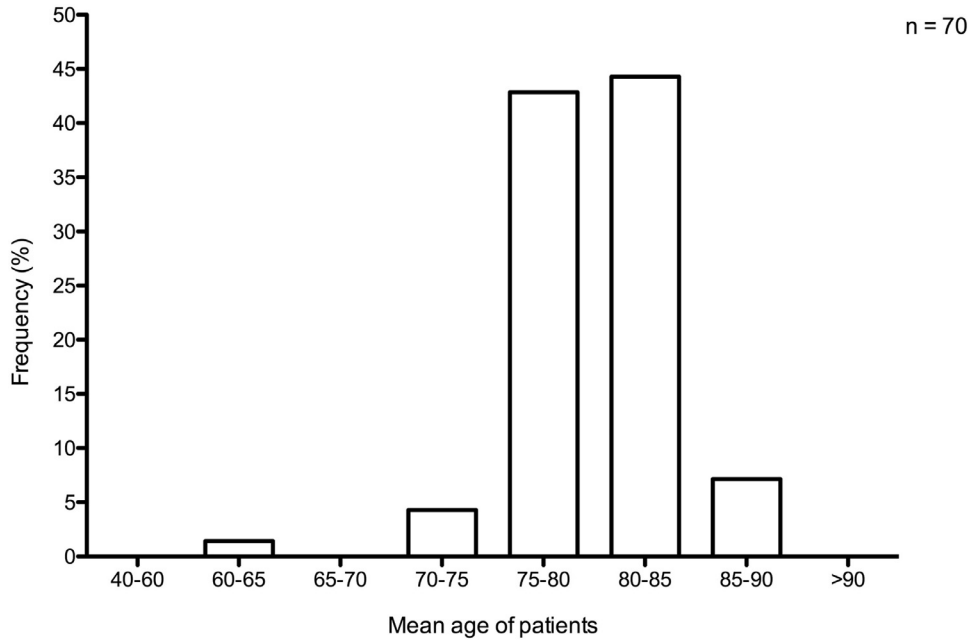


Fig 4. Distribution of the mean age of patients undergoing TAVR.

output monitoring (4%), and central venous pressure (61%). Transesophageal echocardiography (TEE), whether performed by an anesthesiologist or cardiologist, only was used $\leq 30\%$.

Norepinephrine was the first-line vasopressor in 63%, whereas phenylephrine (20%), metaraminol (11%), ephedrine (3%), and dobutamine (1%) less commonly were used. In 1%, no vasopressor was used during MAC.

Postprocedural Care

Most patients were transferred to an intensive care unit (ICU) (51.43%) followed by post-anesthesia care unit

(27.14%), postoperative recovery room (11.43%), or directly to the normal ward (10%). Interesting to note was that in 50% of TAVR cases, patients were transferred directly to the normal ward in Italy. In 52% of the responses the provided “nurse-to-patient ratio” was 1:2, and 1:3 ratios were reported in 26%, 1:4 in 20%, and 1:6 in 2%. Intravenous pacing leads were left in situ after TAVR in 62% according to the responses.

If life-threatening complications emerged, maximum care for every patient (including cardiac surgery) was provided in 43%. In 53% the members stated that an individualized interdisciplinary team decision for every patient was made. In 4%

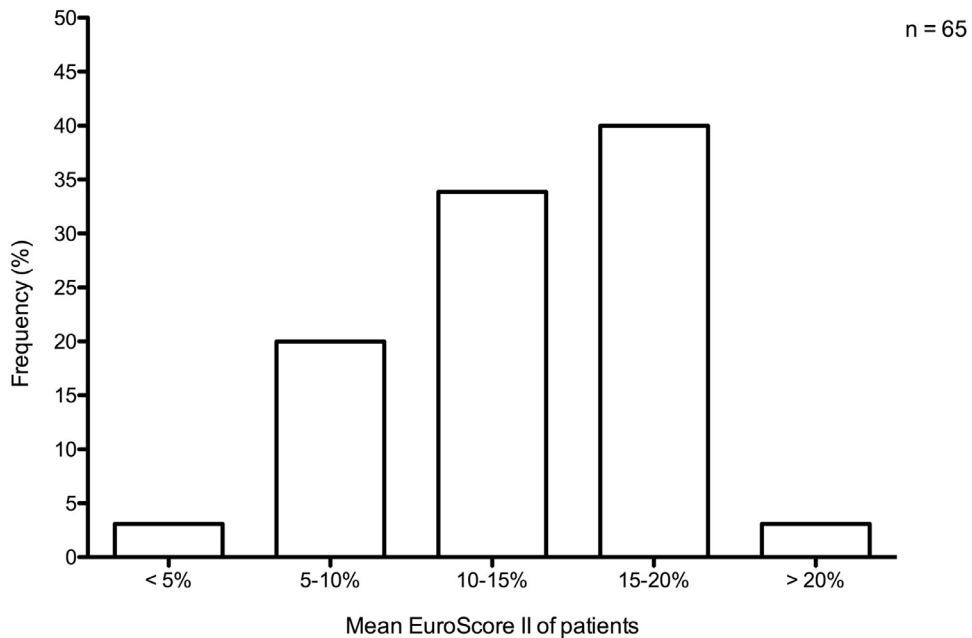


Fig 5. Distribution of the mean EuroScore II of patients undergoing TAVR.

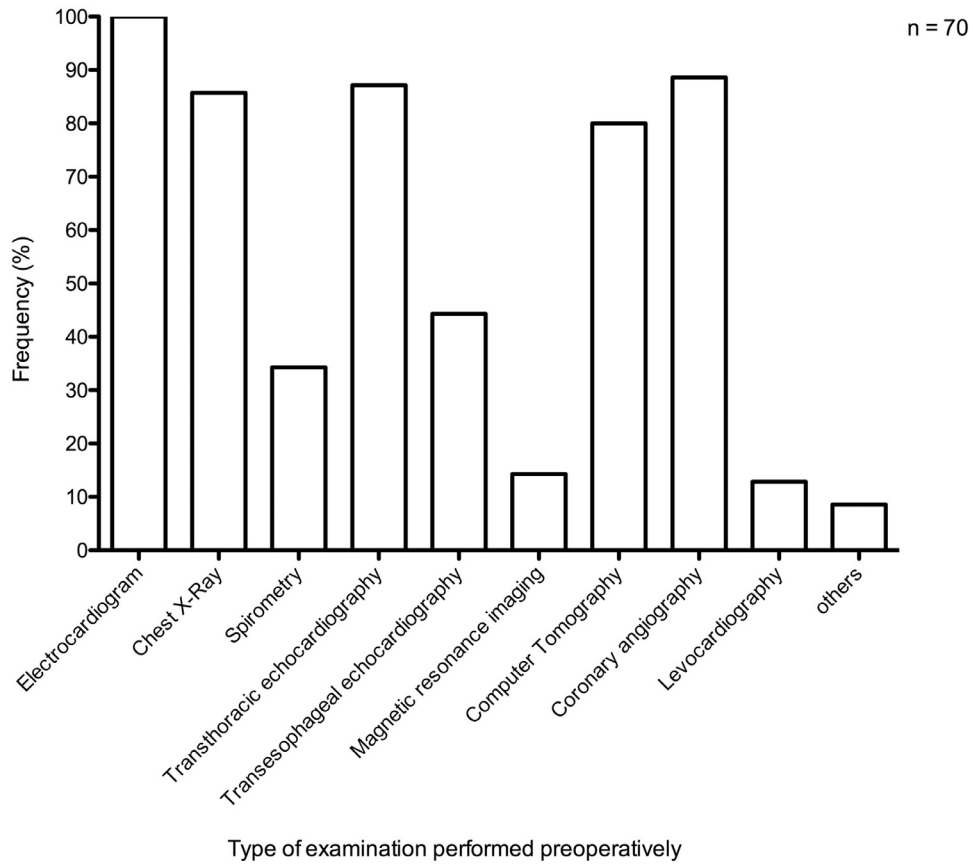


Fig 6. Frequency of routinely performed preoperative diagnostic exams in the TAVR evaluation.

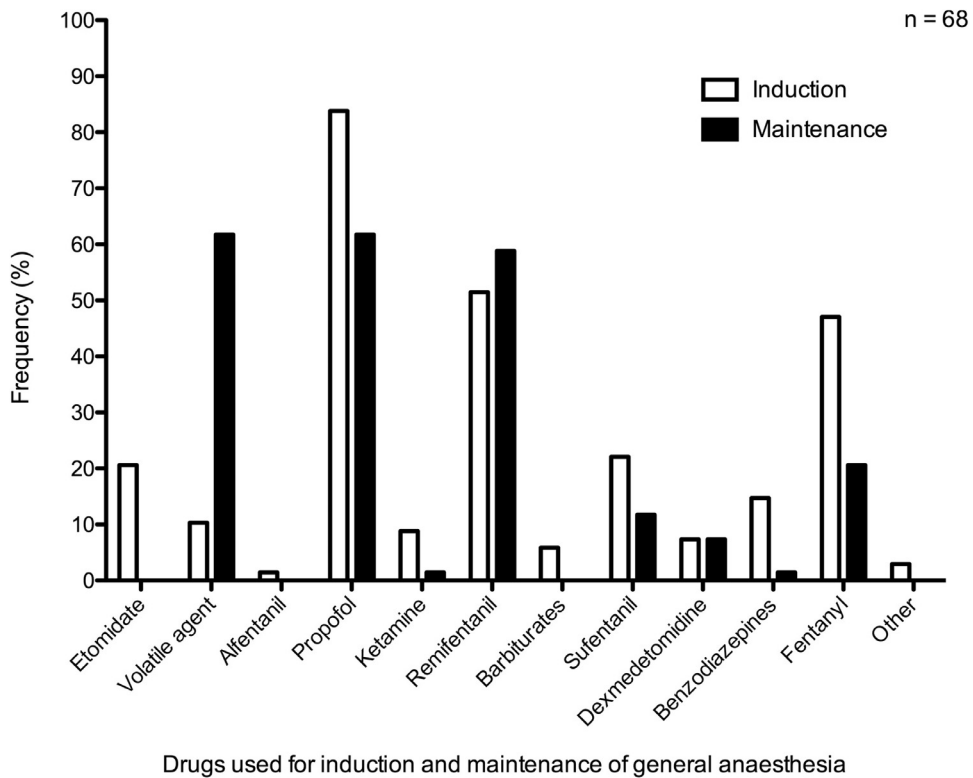


Fig 7. Frequency of drugs used for induction and maintenance of general anaesthesia for TAVR.

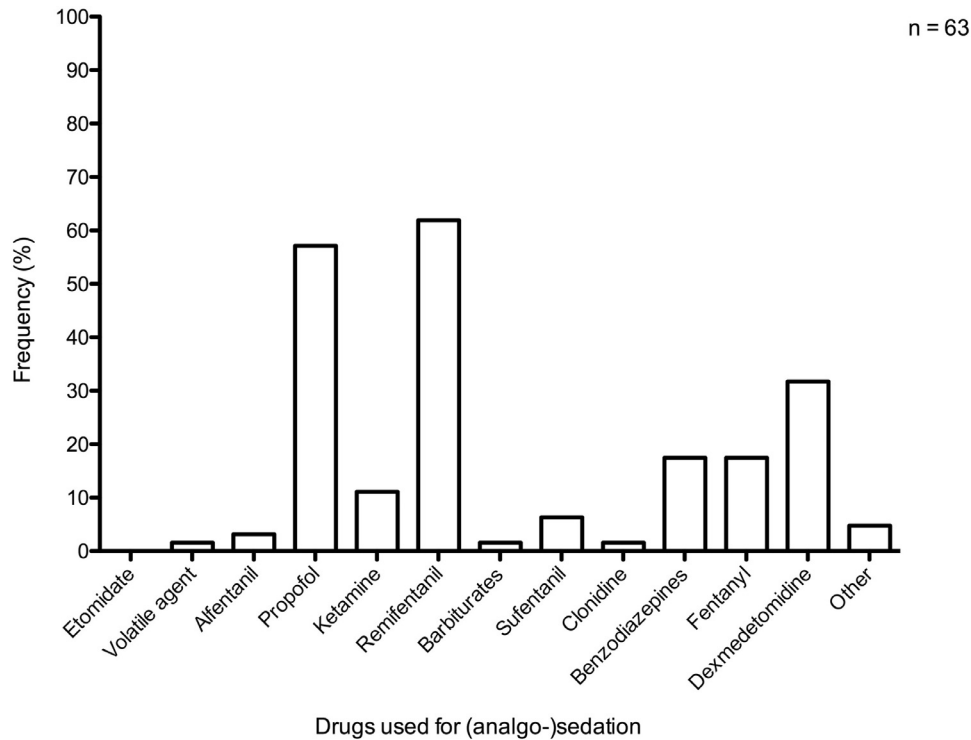


Fig 8. Frequency of drugs used for (analgo-)sedation for TAVR.

the therapy goal was switched to palliative care according to end-of-life decisions that were gathered preoperatively.

Only unfractionated heparin (87%) or low-molecular-weight heparin (13%) were used periprocedurally for anticoagulation. Other types of anticoagulants were not used.

Discussion

The results of the survey provided a rough overview of the current situation of perioperative care for TAVR patients in Europe in late 2018. The results indicated that the requirements and quality indicators defined in the European guidelines were largely, yet not fully, being implemented in daily routine across Europe.^{1,13,14} This held especially true concerning the periprocedural role of the anesthesiologist. Survey participants replied that an anesthesiologist was present in 91% over the whole TAVR procedure. Interestingly, only 60% stated that the decision for TAVR was made preoperatively by an interdisciplinary heart team, including an anesthesiologist. Moreover, a national curriculum for cardiothoracic anesthesia existed in merely 34% of members reporting, although 95% replied that a cardiothoracic anesthesiologist was available around the clock every day at the respective hospital. In preparation for TAVR, only 77% of the participants performed a CT, although multislice CT is the preferred imaging tool for the anatomy and dimensions of the aortic root and valve annulus, as well as access site and route and superior compared with cardiovascular magnetic resonance and TEE.¹⁵

The latest guidelines on heart valve disease, endorsed by the European Society of Cardiology and the European Association for Cardiothoracic Surgery, put strong emphasis on the

concept of the Heart Team, a multidisciplinary team consisting of cardiac surgeons, cardiologists, cardiac anesthesiologists, and other professions in the planning and indication process for TAVR.^{1,14} Adherence to the concept of a heart team is thought to result in a better quality of care. However, this study revealed regional differences concerning the adherence to the guidelines and recommendations. Interestingly, members of 8 countries who took part in this study stated that no anesthesiologist was part of the heart team. This was in line with results of the European Surgical Outcomes Study (EUSOS) examining clinical outcomes after major noncardiac surgery, which also found regional differences in mortality rates among 28 European countries.¹⁶ These countries had higher mortality rates, although not statistically significant, compared with the United Kingdom in the EUSOS study. In contrast, 3 countries, in which anesthesiologists were not part of the heart team, showed lower mortality rates than that of the EUSOS study.¹⁶ Moreover, a cardiac anesthesiologist should be embedded in heart valve centers,^{14,17} highlighting the importance of a structured curriculum and training in cardiothoracic anesthesia. Interestingly, such a quality (training) program, which refers to subspecialty cardiac anesthesiology training in the form of a fellowship, was found to be implemented in only two-thirds of the study participants.

TAVR implantation was performed under GA and MAC in >80% of the responses. This was in accordance with previous studies dealing with anesthetic care during TAVR.⁸ Various observational and registry data, as well as meta-analyses and prospective studies comparing the outcome between the methods have shown ambiguous results. Shorter procedural time, decreased hospital length of stay, reduction in the incidence of

postoperative delirium, decreased pulmonary and major access-site complications, and a decrease in hypotensive episodes with consecutive lesser need for inotropes and adrenergic therapy compared with GA have been associated with MAC, previously described as conscious sedation.^{7,8,10,13,18-24} In contrast, no differences regarding the incidence of long-term mortality, myocardial infarction, or stroke between the 2 aforementioned techniques occurred,^{7,8,10,12,13,18,19,22,24,25} whereas results concerning 30-day mortality were ambiguous.^{7,8,19,22-25} Moreover, as pointed out in an editorial by Hutchinson, institutions with less experience in the TAVR procedure chose GA as the preferred mode in most cases due to patient safety reasons.²⁶ The SOLVE-TAVI trial, a 2 × 2 randomized trial comparing self-expandable and balloon-expandable valves, as well as general and conscious sedation with local anesthesia, showed that the latter anesthetic concept was equivalent to GA regarding the composite of all-cause mortality, stroke, myocardial infarction, infection rate requiring antibiotic treatment, acute kidney injury, procedure times, valve-related, or clinical outcome, but differed regarding the rate of catecholamine used. Results were presented at the 30th Annual Transcatheter Cardiovascular Therapeutics scientific symposium 2018 in San Diego.

However, 9% of the responses stated that no anesthesiologist was present during TAVR, and there were regional differences across Europe concerning the availability of anesthesiologists in the respective heart centers. According to the standards defining a heart valve center, defined by the European Society of Cardiology working group on valvular heart disease and the European Association for Cardiothoracic Surgery, such a center must have cardiac anesthesia.¹⁴

In case of GA, propofol, remifentanyl, and volatile agents were the most common agents for induction and maintenance, whereas propofol, remifentanyl, and dexmedetomidine were mostly used for MAC. Studies in TAVR patients comparing the medication regimen used did not show any differences in outcome.^{19,27-30} In contrast, the application of dexmedetomidine in postoperative cardiac surgery patients was associated with differences in outcome. In a recent meta-analysis by Wang et al., including 18 randomized controlled trials with 1,730 patients, it could be shown that it could reduce the severity of hemodynamic instability and length of stay in the intensive care in cardiac surgery patients.³¹ In another meta-analysis by Liu et al. comprising 8 studies with 969 patients, dexmedetomidine compared with propofol, reduced the risk of delirium and was associated with a shorter length of intubation but a higher incidence of bradycardia.³² However, there seemed to be a beneficial effect of volatile anesthetics on diastolic function in patients with heart failure with preserved ejection fraction as opposed to intravenous hypnotics in cardiac surgery patients.^{32,33}

Echocardiography is an integral part of the preoperative TAVR evaluation process besides CT or coronary angiography. Only 26% and 30% of the participants responded that an intraprocedural TEE was performed by an anesthesiologist or cardiologist, respectively.¹ Data from the France-2 registry demonstrated that TEE can reduce the incidence of

postprocedural aortic regurgitation,¹³ and data from the Brazilian registry showed that the use of TEE can be a protective factor against overall and late mortality.³⁴ Bagur et al. found no significant difference between angiography and TEE for TAVR guidance regarding the incidence of aortic regurgitation and survival rate, but could show a reduced time of procedure and amount of contrast media applied.³⁵ In the SOLVE-TAVI trial, only 33.6% and 3.8% of the patients receiving GA and MAC, respectively, had an intrainterventional TEE. Until today, there were no randomized controlled trials to examine if the performance of a TEE changed outcomes. There were incoherent results on whether the type of anesthesia favored or restricted the incidence of postprocedural aortic regurgitation.^{13,19,23,24} Although previously seen as an obstacle to performing perioperative TEE, several centers undertake it routinely using sedation, which is also in accordance with recent recommendations.³⁶⁻³⁸ Furthermore, TEE is seen as an integral part of the preintervention selection of suitable patients, as well as the intraprocedural monitoring.³⁹ Yet only 45% of the responders replied that a preoperative TEE regularly was performed. However, if TEE is performed, it should be undertaken by a properly trained examiner. Several guidelines addressing training and maintenance of competence in TEE have been published.^{39,38}

In 78% of responses, patients after TAVR were transferred to a unit with intermediate or intensive care capacity, with a nurse-to-patient ratio of 1:2 to 1:3. Interestingly, in 10%, patients were treated after intervention on a normal ward without further ICU monitoring (eg, continuous ECG/SpO₂/invasive blood pressure). Whether or not intensive care capacity in those centers existed or other reasons for not transferring patients to an ICU were not questioned by this survey. Regardless of this, European guidelines demand the availability of intensive care units in heart valve centers.¹⁴ In 62% the intravenous pacing leads were left in place after TAVR. In a previously conducted online survey completed by 250 centers with a cumulative experience of nearly 70,000 TAVR implantations, 60% of the questioned centers maintained continuous ECG monitoring for fewer than 48 hours.⁵ As recommended by the Valve Academic Research Consortium-2 initiative, continuous rhythm monitoring after TAVR is recommended up to 72 hours.⁴⁰ Atrial fibrillation and atrioventricular blockage are the most prevalent conduction disturbances after TAVR implanted through the transapical approach. Left atrial dilation is the most important predictor for atrial fibrillation, whereas aortic valve prosthesis depth within the left ventricle, routine valve oversizing, interventricular septal thickness, balloon valvuloplasty with an oversized balloon, as well as aortic valve calcification, are the most important ones for atrioventricular blockage.⁴¹

This study had several shortcomings. As this was a survey mainly among members of EACTA, the authors hope that it reflected overall European practice. However, the authors cannot be sure, due to the voluntary approach and overall low response rate of the survey, that the response of study participants in a country will be comparable to different centers in the same country. Nevertheless, members of EACTA

practicing in 16 European countries answered. Reasons for differences in TAVR care among different members were not requested. The survey was not validated before its use and internal consistency was not tested. Increments in ranges of numbers were not equal. An effective response rate for the survey was not determined beforehand.

Conclusion

The results indicated that the requirements and quality indicators defined in the European guidelines were largely, yet not fully, being implemented in daily routine. TAVR procedures are performed heterogeneously throughout Europe even after publication of the recent guidelines. This especially includes perioperative anesthetic management, as an anesthesiologist is not even present and involved in all cases. In addition to the published European guidelines, facilities may consider setting up and implementing guidelines especially for the proper anesthetic training and management in TAVR. In this context, the German Federal Joint Committee already has published guidelines defining requirements for structural and process quality issues concerning the indication, implementation, and inpatient care of patients for whom a TAVR is performed (<https://www.g-ba.de/english/structure/>). The results of this study could help in the development of such European guidelines.

Conflict of Interest

R.F.T., M.N., M.B., J.B., S.B., J.E., J.M.E., J.F., N.F., C.M., M.P., J.V.D.M., and P.W. have nothing to declare. F.G. received honoraria for lectures and advisory board meetings from Amomed, Baxter, Edwards, Masimo, and OrionPharma, Masimo outside this work. S.T. received honoraria for lectures from Edwards, Carinopharm, OrionPharma and Smith & Nephews outside this work.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:[10.1053/j.jvca.2020.09.088](https://doi.org/10.1053/j.jvca.2020.09.088).

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