Original Article

Choice of anesthesia technique is associated with earlier hospital discharge and reduced costs after transcatheter transfemoral aortic valve implantation

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Background: Transcatheter aortic valve implantation (TAVI) has become a viable alternative to palliation in patients with severe aortic stenosis. We compared general anesthesia to conscious sedation for TAVI procedures with respect to post operative morbidity, hospital length of stay, and financial burden.

Methods: We conducted a retrospective review of prospectively collected data in patients undergoing transfemoral TAVI procedures from 2012 to 2017. Patients were matched based on age and sex and classed into either general anesthesia or conscious sedation groups respectively. Conscious sedation was provided with a dexmedetomidine infusion, and patients in general anesthesia group received a standard induction, tracheal intubation, and maintenance with sevoflurane. The hospital case costs were compared between the two groups before and after adjustment for inflation.

Results: We matched 124 pairs for a total of 248 patients. Both groups were similar with respect to demographic data, past medical history, medications, and intraoperative characteristics. There was no difference in postoperative morbidity and mortality between the two groups. The median hospital length of stay was 5 [interquartile range (IQR): 3, 10] and 7 (IQR: 4, 12) days, P=0.01, and after adjustment for inflation, the total hospital case costs were $48,984 (IQR: $44,802, $61,438) Canadian (CAD) *vs.* $55,333 (IQR: $46,832, $68,702) CAD, P=0.01, in the conscious sedation and general anesthesia groups, respectively.

Conclusions: Advancements in TAVI technologies, conscious sedation and a collaborative, multidisciplinary team approach reduces overall length of hospital stay and procedure costs.

Keywords: Transcatheter aortic valve implantation (TAVI); general anesthesia; conscious sedation; length of stay; costs

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Introduction

Degenerative aortic stenosis is the most common valvular heart disease in the elderly. The prevalence of moderate to severe aortic stenosis reaches 4% at 65 years old and 5% at 85 years old (1,2). Although conventional open surgical aortic valve replacement is considered the optimal therapy for severe symptomatic aortic stenosis, approximately one-third of patients with aortic stenosis are not candidates for open heart surgery due to multiple comorbidities and prohibitive mortality risk related to the surgical procedure (2). For these patients, the minimally invasive, minimal access transcatheter aortic valve implantation (TAVI) procedure has become a viable alternative to palliation (3).

TAVI is a well-established option compared to conventional aortic valve replacement with its non-inferiority in 1-year survival (4), however, there is an ongoing debate as to the best choice of anesthetic technique to use for TAVI, highlighting the pros and cons for general anesthesia *vs.* conscious sedation with local anesthesia (5). The anesthetic management of TAVI differs greatly between different cardiac centers depending on numerous factors including surgical preference, volume of procedures performed, and the method of echocardiography guidance used and cardiac team experience.

Historically, general anesthesia was the technique of choice in most cardiac centers at inception of their TAVI program. This facilitated intra-procedure team discussions, transesophageal echocardiography (TEE) guidance, and patient stability, but longer procedure times. However, with greater team experience, smaller delivery systems, advances in device design, and less reliance on TEE to guide the valve positioning, a shift towards less invasive anesthesia techniques has been observed. A number of advantages of conscious sedation have been highlighted by recent studies increasing its popularity, including reduced procedural times, decreased need for vasopressor support, and reduced hospital length of stay (2).

Our institution performed its first TAVI 20 years ago, in 2003. Subsequently, over the last decade there has been a shift towards the transfemoral access site rather than the transapical approach. Our group, have gradually introduced conscious sedation anesthesia supplemented by local anesthetic infiltration at the femoral puncture site in place of general anesthesia. Since 2015, this anesthesia technique has become the anesthesia method of choice in over 90% of our TAVI patients. Although both the general anesthesia and conscious sedation anesthesia techniques for transfemoral TAVI procedures have been previously compared in several studies confirming noninferiority with either technique (6-8), the cost implications have not been adequately addressed. The purpose of the current study was to compare general anesthesia and conscious sedation with respect to postoperative morbidity and mortality as well as the cost containment and length of hospital stay. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1739/rc).

Highlight box

Key findings

- Conscious sedation when compared to general anesthesia is associated with shorter hospital length of stay and lower overall costs in patients undergoing transfemoral transcatheter aortic valve implantation (TAVI) procedures.

What is known and what is new?

- TAVI is a well-established option compared to conventional aortic valve replacement with its non-inferiority in 1-year survival.
- There is an ongoing debate as to the best anesthesia technique in patients undergoing TAVI procedures.
- Conscious sedation is associated with shorter hospital length of stay and lower overall costs in after TAVI procedures.

What is the implication, and what should change now?

- The current study confirmed the non-inferiority in patient-centered outcomes between general anesthesia and conscious sedation.
- Conscious sedation technique should be given a preference over general anesthesia to reduce hospital length of stay and contain procedure costs after TAVI procedures.

Methods

The current study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Institutional Research Ethics Board (#15-9876) at Toronto General Hospital, and individual consent for this retrospective analysis was waived. Our database was interrogated for patients undergoing transfemoral TAVI procedures from 2012 to 2017. Based on the type of anesthesia administered, patients were classed into general anesthesia or conscious sedation groups respectively. The two groups were compared based on 1:1 matching pertinent to age and sex. If a perfect match for age could not be achieved for a particular pair of patients, a one-year difference between the two patients was accepted. Patients with a history of psychiatric disease, delirium, dementia or those undergoing emergency procedures were excluded. Patients who were converted to general anesthesia during the procedure were also excluded from the analysis.

In the conscious sedation group, all patients received an infusion of dexmedetomidine 0.5–1.4 mcg/kg/h (with or without a bolus of 0.5 mcg/kg over 15–20 min) until the end of the procedure complemented with aliquots of intravenous fentanyl 25 mcg at the discretion of anesthesiologist in charge of the case. Patients in the general anesthesia group received fentanyl 1–3 mcg/kg and propofol 0.5 mg/kg as an induction of anesthesia, and tracheal intubation was facilitated by rocuronium 0.6 mg/kg. Anesthesia was maintained with sevoflurane 0.5–2% throughout the procedure.

All patients received heparin, 100 IU/kg before deployment of the valve. Additional heparin was given if the activated clotting time was less than 300 s. Both the Corevalve (Medtronic, Minneapolis, MN, USA) and the Sapienvalve (Edwards Lifesciences, Irvine, CA, USA) were used. Valve implantation was conducted in a hybrid operating room by a team consisting of interventional cardiologists, anesthesiologists and cardiac surgeons. The femoral artery was accessed, with percutaneous placement of pre-closure devices before the retrograde advancement of the valve delivery system. Balloon aortic valvuloplasty was performed before deployment of the valve, which was facilitated by rapid pacing. Fluoroscopy and transesophageal (general anesthesia group) or transthoracic (conscious sedation group) echocardiography were used to guide the optimal placement of the valve. Anticoagulation was reversed with protamine at the end of each procedure.

In the general anesthesia group, patients were extubated in the operating room immediately after the procedure. All patients were transferred to either the coronary care unit or the cardiovascular intensive care unit, depending on bed availability. Postoperative analgesia included opioid analgesics, non-opioid adjuncts such as nonsteroidal anti-inflammatory drugs (if there were no contraindications), and acetaminophen as needed.

Statistical analysis

Descriptive statistical analysis was performed for all variables measured before and after TAVI procedures. The comparability of both groups was assessed with *t*-test or Mann-Whitney *U* test for continuous normally distributed and non-parametric data. The chi-square statistics or Fisher's Exact test were used for categorical data analysis. The cost comparison between the groups was made based on the Ministry of Health and Long-Term care Ontario case costing standards 2014–2015, version 9.1 (9). The calculated costs included variable direct labor, variable direct supplies (general and patient specific), fixed direct labor, fixed direct equipment, indirect variable, and indirect fixed. For simplicity, the sum of all costs was compared between the two groups. The hospital case costs were compared between the two groups before and after adjustment for inflation. A P value of 0.05 was considered statistically significant. Statistical analysis was conducted with the use of MINITABs statistical software (Minitab Inc., State College, PA, USA).

Results

We matched 124 pairs of patients for a total of 248 patients. Both groups were similar based on demographic data, past medical history and medications (*Table 1*). Intraoperative characteristics and postoperative outcomes are reflected in *Table 2*. There was no difference with respect to postoperative morbidity and mortality between the two groups. Although operating room time was slightly shorter in the conscious sedation group, 119 *vs.* 128 min, it did not reach statistical significance. In the conscious sedation group, the median hospital length of stay was 5 [interquartile range (IQR): 3, 10] days compared to 7 (IQR: 4, 12) days in the general anesthesia group, P=0.01. When adjusted for inflation, the median postoperative case care costs and the total case care costs were $47,067 CAD *vs.* $52,857 CAD, and $48,984 CAD *vs.* $55,333 CAD in the conscious sedation and the general anesthesia groups, respectively, P=0.01 (*Table 3*).

Discussion

The main findings of this study are that conscious sedation when compared to general anesthesia is associated with shorter hospital length of stay and lower overall costs in patients undergoing transfemoral TAVI procedures. Our findings were consistent with several previous reports confirming shorter length of stay and lower health care costs with the conscious sedation strategy (5-7,10-12).

Historically, there has been a gradual increase in the proportion of patients receiving conscious sedation with local anesthesia. A 2017 report from the National Cardiovascular Data Registry identified that 15.8% of 10,997 patients underwent conscious sedation for TAVI procedures (5). The German aortic valve registry [2011–2014] quoted that local anesthesia and conscious sedation was administered in 49% of 16,543 patients (13). According to an analysis of the data from the American College of Cardiology Transcatheter Valve Therapy Registry, from April 2014 to June 2015 there was an increase from 11% per quarter to 20% per quarter in the use of conscious sedation as the choice of anesthetic technique for TAVI (6). Furthermore, more recent report from the same registry

Table 1 Baseline demographics data of patients undergoing transfemoral transcatheter aortic valve implantation

Variables	Conscious sedation group (n=124)	General anesthesia group (n=124)	P value
Demographics			
Age (years)	82 [76, 88]	82 [76, 88]	0.98
Male	74 [60]	74 [60]	>0.99
Body mass index (kg/m^2)	28 [24, 32]	27 [24, 30]	0.70
ASA status	4 [3, 4]	4 [3, 4]	0.37
Past medical history			
Diabetes mellitus	44 [35]	38 [31]	0.49
Hypertension	100 [81]	111 [90]	0.07
Stroke	15 [12]	18 [15]	0.70
Peripheral vascular disease	12 [10]	14 [11]	0.83
Chronic obstructive pulmonary disease	24 [19]	24 [19]	>0.99
Dialysis	2 [2]	0 [0]	0.49
Coronary artery disease	70 [56]	64 [52]	0.52
Myocardial infarction	79 [64]	76 [61]	0.79
Congestive heart failure	47 [38]	43 [35]	0.69
Atrial fibrillation	12 [10]	18 [15]	0.33
Medications			
Aspirin	77 [62]	83 [67]	0.50
Beta-blockers	59 [48]	63 [51]	0.70
Angiotensin converting enzyme inhibitors	38 [31]	41 [33]	0.78
Calcium channel blockers	31 [25]	31 [25]	>0.99
Statins	80 [65]	89 [72]	0.27
STS-TAVR in-hospital predicted mortality risk (%)	2.8 [2.2, 3.6]	3.0 [2.4, 3.8]	0.50

Data expressed as median [interquartile range], and number of patients [%]. ASA, American Society of Anesthesiology; STS, Society of Thoracic Surgeons; TAVR, transcatheter aortic valve replacement.

Table 2 Intraoperative characteristics and postoperative outcomes after transcatheter transfemoral aortic valve implantation

Outcomes of interest	Conscious sedation group (n=124)	General anesthesia group (n=124)	P value
Operating room time (min)	119 [105, 139]	128 [106, 155]	0.07
STS-TAVR in-hospital predicted mortality risk (%)	2.8 [2.2, 3.6]	3.0 [2.4, 3.8]	0.5
Hospital mortality	2 [2]	4 [3]	0.68
Postoperative delirium	8 [6]	10 [8]	0.80
Myocardial infarction	2 [2]	2 [2]	>0.99
Stroke	3 [2]	3 [2]	>0.99
Dialysis	2 [2]	0 [0]	0.49

Data expressed as median [interquartile range], and number of patients [%]. STS, Society of Thoracic Surgeons; TAVR, transcatheter aortic valve replacement.

Table 3 Hospital length of stay and hospital case costs

Variables	Conscious sedation group (n=124)	General anesthesia group (n=124)	P value
Hospital length of stay (days)	5 [3, 10]	7 [4, 12]	0.01
Hospital case costs			
Unadjusted ($CAD)			
Total	39,385 [35,460, 51,655]	44,165 [36,336, 56,825]	0.03
Postoperative	37,718 [24,213, 45,767]	41,912 [35,837, 51,752]	0.02
Adjusted for inflation ($CAD, 2023)			
Total	48,984 [44,802, 61,438]	55,333 [46,832, 68,702]	0.01
Postoperative	47,067 [43,626, 55,378]	52,857 [46,038, 62,452]	0.01

Data expressed as median [interquartile range]. CAD, Canadian.

comprising 120,080 patients identified that 75% of patients received conscious sedation for TAVI (11). This demonstrates a wide variation in practice across different institutions worldwide. The 'pro' and 'con' debate regarding the routine use of conscious sedation *vs.* general anesthesia for patients undergoing TAVI procedures still continues in 2023 (14,15).

Advocates for general anesthesia in TAVI would argue that the major advantage of tracheal intubation is the superiority of TEE imaging *vs.* transthoracic echocardiography in guiding the valve positioning, particularly with respect to detection of paravalvular leaks. Furthermore, general anesthesia provides a seamless transition to full sternotomy with the initiation of cardiopulmonary bypass in case of emergency, where it is deemed appropriate. Emergency conversion to general anesthesia may occur in up to 5% of patients (16). However, general anesthesia may be associated with higher requirements for vasoactive medications (6), and the use of TEE is not devoid of serious complications (17).

Creating a 'TAVI team' allows for multidisciplinary input from all stakeholders, and anesthesiologists are a vital component of this team. With increasing caseload and experience there is a trend away from general anesthesia towards a less invasive approach, using conscious sedation. Some European centers have advocated for performing TAVI procedures under local anaesthesia with only mild analgesic and antiemetic medication without surveillance by any anaesthesiologist. However, 7 (1.5%) out of 461 patients in this particular report required either hemodynamic support or cardiopulmonary resuscitation, both necessitating the urgent presence of an anesthesiologist (18).

Conscious sedation is a broad term that can apply to a wide variety of anesthesia/sedation combinations. The commonly used medications include dexmedetomidine, propofol, benzodiazepines, and/or narcotic analgesics. At our institution, we used dexmedetomidine as our primary sedative in all TAVI procedures. Dexmedetomidine has many favorable characteristics which make it an ideal agent in this group of elderly patients. Currently, it is fair to say that the efficacy and safety of conscious sedation in providing optimal conditions for TAVI are well established. Our study is a retrospective analysis of data in the second decade after we initiated our TAVI program. As with all large TAVI centers there is a learning curve involved from both the interventional providers' and the anesthesia providers' perspective. During the learning period our institution employed general anesthesia and TEE as the primary choice. In line with most international centers, as all 'TAVI team' members become more proficient and comfortable with the procedure and evolving technology there is natural gravitation towards conscious sedation and transthoracic echocardiography as the preferred strategy. In the absence of difference in morbidity and mortality between the conscious sedation and general anesthesia groups, the evolving 'TAVI team' strategies are the most likely explanation for the shortened length of hospital stay in these patients. In the presented study, cost analysis showed a significant difference between the use of conscious sedation and general anesthesia with an average decrease in mean cost of 15% seen with the use of conscious sedation. One of the major components of cost savings was a reduction in hospital length of stay. Pushing limits even further, there have been attempts to perform TAVI procedures as the next day discharge or even same day discharge from the hospital (19).

The current study has several limitations. As stated above, our institution moved to conscious sedation as the primary anesthesia technique for TAVI in 2015, which falls in the middle of the analysis period (2012–2017). Consequently, it is possible that most of the conscious sedation patients coincided with the latter half of the study period and that the general anesthesia group fell primarily towards the beginning of this 5-year analysis period. In addition, the evolving 'TAVI team' strategies, the convergence of other technological and procedural advances in TAVI that might have been differentially applied to the latter period all contributed to reduced length of hospital stay. So, it is important to emphasize that it is this focused and concentrated team effort rather than one single element that contributed to reduced overall costs. Even though both groups of patients were similar with respect to major underlying comorbidities at baseline, there may have been some subtle confounding differences between the two groups that were not accounted for but contributed to longer length of hospital stay in the general anesthesia group. Furthermore, we did not perform a formal patient satisfaction analysis comparing the two strategies, however, informal patient assessments leaned towards preference for conscious sedation. Finally, we did not study the long-term outcomes looking at 1- or 2-year morbidity and mortality and re-admission rates to the hospital. These questions would need to be answered in future studies.

Conclusions

In conclusion, advancements in TAVI technologies, tailored conscious sedation to facilitate a quiet procedural field while meeting patient's expectations and a collaborative, multidisciplinary team approach reduces overall length of hospital stay and procedure costs.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1739/rc

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The current study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Institutional Research Ethics Board (#15-9876) at Toronto General Hospital, and individual consent for this retrospective analysis was waived.

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