

The Safety and Feasibility of Gastrointestinal Cancer Surgery with the Aid of Balloon Aortic Valvuloplasty in Patients with Severe Aortic Stenosis

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ABSTRACT

AIM: Patients with severe aortic stenosis (AS) have been considered to be high-risk patients for noncardiac surgery. We evaluated the safety and feasibility of gastrointestinal (GI) cancer surgery after performing balloon aortic valvuloplasty (BAV) in patients with severe AS.

METHODS: A total of 16 patients who diagnosed with GI cancer and simultaneously met the criteria for AS intervention were included in this study. In our hospital, indications for AS intervention are as

follows: (1) peak aortic valve velocity of > 4 m/sec and presence of exertional dyspnea; or (2) peak aortic valve velocity of > 5 m/sec. Our policy defined that cancer patients who meet these criteria undergo BAV in order to reduce the risk of noncardiac surgery for the treatment of cancer. We evaluated the outcomes of BAV and GI cancer surgery.

RESULTS: The echocardiographic data of AS was significantly improved after BAV. After BAV, mitral regurgitation occurred in 1 patient and transcatheter aortic valve implantation was required before GI cancer surgery in 1 patient. However, all enrolled patients proceeded to GI cancer surgery, which was performed uneventfully.

CONCLUSION: We demonstrated the safety and feasibility of GI cancer surgery after performing BAV in patients with severe AS. GI cancer surgery can be performed even in high-risk severe AS patients.

Key words: Balloon aortic valvuloplasty; Gastrointestinal cancer surgery; Noncardiac surgery; Severe aortic stenosis

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INTRODUCTION

Patients with severe aortic stenosis (AS) have been considered to be extremely high-risk patients for noncardiac surgery^[1,2]. According to the 2014 American College of Cardiology/American Heart Association guidelines, elective noncardiac surgery in patients who have indications for aortic valve replacement should be deferred^[3]. These guidelines also suggest that asymptomatic patients with severe AS who have no evidence of left ventricular dysfunction can undergo moderate-risk noncardiac surgery. Preoperative balloon aortic valvuloplasty (BAV) is considered to be one of the options to

enable patients with severe AS to undergo noncardiac surgery, but the effectiveness of BAV remains controversial^[4].

Under these complex conditions, we have performed gastrointestinal (GI) cancer surgery after performing BAV as a preoperative therapy in patients with severe AS. We evaluated the safety and feasibility of GI cancer surgery after performing BAV in patients with severe AS.

PATIENTS AND METHODS

From January 2007 to December 2017, a total of 23 patients underwent surgery after BAV in our department. Among them, 16 patients had diagnosed with GI cancer were included in this study. Patients undergoing emergency operations or with benign diseases were excluded in this study. They were included in a retrospective registry.

In our hospital, indications for the intervention for AS are as follows: (1) peak aortic valve velocity (Vmax) of > 4 m/sec and presence of exertional dyspnea; or (2) Vmax of > 5 m/sec. In principle, cancer patients who meet these criteria undergo BAV in order to reduce the risk of noncardiac surgery for the treatment of cancer. All patients in this study met these criteria for AS intervention and underwent BAV. The reasons for undergoing BAV instead of definitive AS interventions are: (1) artificial cardiac valve implantation via aortic valve replacement (AVR) or transcatheter aortic valve implantation (TAVI) requires antiplatelet therapy, which may increase the risk of bleeding from known cancer or noncardiac surgery; and (2) the artificial cardiopulmonary systems used in AVR may also increase the risk of massive bleeding from known cancer.

We evaluated the included 16 patients from medical records, including demographic characteristics, echocardiographic data, procedural results of BAV and GI cancer surgery, and clinical status after BAV and GI cancer surgery.

The patients' cardiac symptoms were evaluated using the New York Heart Association (NYHA) classification. Echocardiographic measurements were performed before and after BAV; patients who did not undergo GI cancer surgery immediately after BAV also underwent echocardiographic measurements before GI cancer surgery. The time of GI cancer surgery and the definitive intervention of AS after BAV were at each surgeon's discretion.

BAV was performed via the transfemoral retrograde approach. The balloon's size was chosen based on the aortic annulus diameter assessed via preprocedural CT. An endocavitary electrode was placed in the right ventricle to obtain rapid pacing during ballooning.

All GI cancer operations were performed as curative resection. The choice of laparoscopic or open surgery depended on each surgeon.

Continuous values in the echocardiographic data were presented as a mean \pm standard deviation. Continuous values in the other data were expressed as a median with range. Differences between continuous variables were assessed by Student's *t* test. Statistical analysis was performed using JMP®11.0.0. *P* < 0.05 was considered statistically significant.

RESULTS

Baseline characteristics

The median age of enrolled patients was 85.5 years (64-94). All patients were symptomatic at baseline. Three patients were classified as NYHA class I, 10 patients as class II, and 3 patients as class III. Four patients had chronic heart failure. Five patients had some kinds of arrhythmia. Two patients had concomitant coronary artery disease. All patients diagnosed with GI cancer; gastric cancer in 6 patients,

colon cancer in 9 patients and rectal cancer in 1 patient. The patients' baseline characteristics are shown in Table 1.

Outcomes of BAV

The echocardiographic data before and after BAV are listed in Table 2. The aortic valve area (AVA) was improved after BAV (from 0.70 ± 0.23 to 0.80 ± 0.16 cm²; *p* = 0.0585). The peak aortic valve gradient was significantly reduced after BAV (from 92.90 ± 21.16 to 73.43 ± 22.14 mmHg, *p* = 0.0008). The mean aortic valve gradient was significantly reduced after BAV (from 53.37 ± 13.60 to 40.67 ± 12.60 mmHg, *p* = 0.0004). Vmax was also significantly reduced after BAV (from 4.79 ± 0.57 to 4.24 ± 0.64 , *p* = 0.0009). Left ventricular ejection fraction slightly improved, but was not statistically significant (from 61.18 ± 9.75 to 63.59 ± 6.80 ; *p* = 0.085). All procedures were followed by GI cancer surgery.

Patient 9 had cardiac heart failure due to mitral regurgitation after BAV, which was treated by conservative treatment. In the rest of all cases, there were no complications after BAV, including death, myocardial infarction, cardiac tamponade, aortic regurgitation, severe arrhythmias, hemorrhage requiring transfusion, and vascular access site problems.

Outcomes of GI cancer surgery

The median duration between BAV and GI cancer surgery was 24.5 days (7-86). Patient 5 refused to undergo GI cancer surgery immediately after BAV and finally underwent laparoscopic sigmoidectomy 86 days after BAV. Among 16 patients, 8 patients underwent open surgery; left hemicolectomy in 1 patient, right hemicolectomy in 1 patient, sigmoidectomy in 1 patient, distal gastrectomy in 4 patients and total gastrectomy in 1 patient, and 8 patients underwent laparoscopic surgery; ileocecal resection in 2 patients, right hemicolectomy in 2 patients, sigmoidectomy in 2 patients, rectal lower anterior resection in 1 patient, distal gastrectomy in 1 patient. The median operation time was 232 min (99-344). The median anesthesia time was 323 min (158-449). The median blood loss was 75 g (20-1020). All patients underwent GI cancer surgery without major intraoperative complications including conversion to open surgery in laparoscopic surgery. All patients quickly recovered and transferred out of ICU on POD1. The median postoperative hospital stay was 13.5 days (7-26). While surgical site infection was observed in 1 case, the postoperative course was uneventful in all cases. Perioperative data of GI cancer surgery are shown in Table 3.

Follow-up after BAV and GI cancer surgery

Eleven patients underwent definitive treatment: TAVI in 6 patients, AVR in 5 patients. The median time of definitive intervention after BAV was 103 days (17-462). After a median follow-up time of 502.5 days (41-1742) after GI cancer surgery, 1 patient had recurrence of cancer and died of recurrence. As for prognosis of AS treatment, 1 patient was in NYHA II and 1 patient died of cardiac failure due to AS. Neither of these 2 patients underwent definitive treatment after BAV. No patients who received definitive treatment experienced cardiac symptom. Among 16 patients, 3 patients died: 1 patient related to AS, 1 patient related to recurrence of cancer, 1 patient related to acute pancreatitis. The clinical status of the patients after BAV and GI cancer are shown in Table 4.

DISCUSSION

We performed GI cancer surgery safely after BAV in high-risk severe AS patients. To the best of our knowledge, this is the first study to

Table 1 Baseline characteristics of 16 patients.

	Age (years)	NYHA†	Chronic heart failure	Arrhythmia	Coronary artery disease	Type of cancer
patient 1	88	II	no	none	no	cecum cancer
patient 2	89	II	yes	none	no	ascending colon cancer
patient 3	75	II	yes	Af‡	yes	sigmoid colon cancer
patient 4	85	II	yes	no	no	gastric cancer
patient 5	80	I	no	Af	no	sigmoid colon cancer
patient 6	79	II	no	no	no	cecum cancer
patient 7	87	I	no	no	no	sigmoid colon cancer
patient 8	89	II	no	no	no	gastric cancer
patient 9	64	III	no	Af+PVC§	no	gastric cancer
patient 10	91	III	no	no	no	gastric cancer
patient 11	84	I	no	no	yes	gastric cancer
patient 12	94	II	yes	Af	no	descending colon cancer
patient 13	86	II	no	no	no	ascending colon cancer
patient 14	83	II	no	no	no	gastric cancer
patient 15	88	II	no	no	no	rectal cancer
patient 16	79	III	no	RBBB¶	no	ascending colon cancer

NYHA†: New York Heart Association; Af‡: atrial fibrillation; PVC§: premature ventricular contraction; RBBB¶: right bundle branch block.

Table 2 Echocardiographic data before and after BAV.

Variable	Baseline	After BAV	P value
AVA† (cm ²)	0.70 ± 0.23	0.80 ± 0.16	0.059
pAVG‡ (mmHg)	92.90 ± 21.16	73.43 ± 22.14	0.001
mAVG‡ (mmHg)	53.37 ± 13.60	40.67 ± 12.60	0.000
Vmax§ (m/sec)	4.79 ± 0.57	4.24 ± 0.64	0.001
LVEF¶ (%)	61.18 ± 9.75	63.59 ± 6.80	0.085

AVA†: aortic valve area; p/mAVG‡: peak/mean aortic valve gradient; Vmax§: peak aortic valve velocity LVEF¶; left ventricular ejection fraction.

Table 3 Outcomes of GI cancer surgery.

Variables	
length between BAV and surgery (days)	24.5 (7-86)
operative procedure (patients)	
open surgery	8
laparoscopic surgery	8
operation time (min)	232 (99-344)
anesthesia time (min)	323 (158-449)
blood loss (g)	75 (20-1020)
postoperative hospital stay (days)	13.5 (7-26)

demonstrate the safety and feasibility of GI cancer surgery after performing BAV. This study is valuable in that we specified only GI cancer surgery, which tends to be invasive.

Patients with severe AS have been considered to be high-risk patients for noncardiac surgery^{1,21}. Predictors that are associated with adverse outcomes in patients with AS during noncardiac surgery are the following: severity of AS, high-risk surgery (vascular surgery), cardiac symptoms, concurrent mitral regurgitation, and coronary artery disease⁵⁻⁸¹. In this study, all patients were symptomatic and met the criteria for AS intervention. They were considered to be high-risk patients for noncardiac surgery, but they successfully underwent GI cancer surgery after BAV, which might involve a relatively invasive procedure.

During perioperative management, tachycardia, systemic hypotension, and the hemodynamic effects of anesthesia as well as surgery should be avoided⁹⁻¹⁴¹. In addition, intravascular volume should be titrated at a level that ensures an adequate forward cardiac output. In this study, even after BAV to relieve the severity of AS, the risk of GI cancer surgery was considered to be so high that we performed careful intraoperative management.

All GI cancer operations were performed as curative resections. The relatively long time operation was included; laparoscopic ileocecal resection took 344 minutes. In addition, the maximum blood loss was 1020 g. However, we did not experience any major intraoperative or postoperative complications. Concerning operative procedure, both open and laparoscopic surgeries were performed safely. This choice depended on each surgeon and was subject to biases, but it is noteworthy that laparoscopic surgery was chosen in more recent cases.

BAV may be useful as a preoperative therapy to noncardiac surgery. BAV is already considered a bridge to definitive treatment by AVR, TAVI or heart transplantation; palliative treatment for patients with contraindication for definitive treatment because of other severe comorbidities; or a preoperative therapy designed to temporally improve hemodynamic status during noncardiac surgery^{15,161}. However, BAV has not been a standard treatment because of its incomplete relief of obstruction and high restenosis rate^{4,171}. In recent studies¹¹⁸⁻²²¹, however, BAV has been reported to be acceptable in high-risk patients with AS (Table 5). BAV, as a preoperative therapy of noncardiac surgery, may be particularly beneficial for patients with severe AS because BAV can sufficiently improve hemodynamic status to lower the risk of noncardiac surgery¹²³¹. In fact, patients after performing BAV successfully underwent noncardiac surgeries in these studies (Table 5), which included various types of surgeries. In our study, mitral regurgitation occurred in 1 patient and TAVI was required before GI cancer surgery because of insufficient effect of BAV in 1 patient, but all enrolled patients proceeded to GI cancer surgery, which was successfully performed. Our results were acceptable in terms of effects of BAV on echocardiographic date and outcomes of BAV and GI cancer operative procedures themselves. We believe that our study is valuable because we experienced a relatively greater number of cases of BAV as a preoperative therapy of GI cancer surgery, which tends to be a more-complex procedure and may be invasive.

While AVR or TAVI is usually performed from 1 week to 6 months after BAV, the appropriate duration between BAV and noncardiac surgery has not been reported. In patient 5, who refused

Table 4 Follow-up after BAV and GI cancer surgery.

Variable	Type of definitive intervention of AS	Time of definitive intervention after BAV (days)	Follow-up time after surgery (days)	Recurrence of cancer	The most recent cardiac symptom	Survival	Cause of death
patient 1	TAVI	267	988	no	stable	yes	-
patient 2	TAVI	64	684	no	stable	yes	-
patient 3	AVR	124	585	no	stable	yes	-
patient 4	none	-	588	no	NYHA II	yes	-
patient 5	AVR	287	384	no	stable	yes	-
patient 6	AVR	55	420	no	stable	yes	-
patient 7	none	-	1445	no	NYHAIV	no	heart failure
patient 8	none	-	41	unknown	unknown	unknown	unknown
patient 9	none	-	42	no	stable	no	acute panperitonitis
patient 10	none	-	361	yes	stable	no	gastric cancer
patient 11	TAVI	462	1742	no	stable	yes	-
patient 12	TAVI	109	1100	no	stable	yes	-
patient 13	TAVI	17	861	no	stable	yes	-
patient 14	AVR	82	361	no	stable	yes	-
patient 15	TAVI	103	173	no	stable	yes	-
patient 16	AVR	94	113	no	stable	yes	-

Table 5 Recent studies of BAV in adult patients with severe AS.

	No. of patients	AVA	AVA after BAV	No. of BAV as a bridge to noncardiac surgery	No. of BAV successfully bridged to noncardiac surgery	Type of surgery
Hamid T <i>et al</i> ^[18]	42	NA	NA	2	2	OS1, OB1
Uchida T <i>et al</i> ^[19]	5	0.56 ± 0.25	0.7 ± 0.27	1	1	GI1
Hui DS <i>et al</i> ^[20]	62	0.69 ± 0.22	0.84 ± 0.27	15	15	unknown
Danic M <i>et al</i> ^[21]	112	0.58 ± 0.18	0.82 ± 0.24	9	9	unknown
Calicchio F <i>et al</i> ^[22]	15	0.52 ± 0.1	1.48 ± 0.4	15	15	TS5 HBP3 BS1 GI2 VS3 OS1
Our hospital	16	0.70 ± 0.23	0.80 ± 0.16	16	16	GI16

Abbreviations: NA: not available; OS: orthopedic surgery; OB: obstetrics; GI: gastrointestinal surgery; TS: thoracic surgery; HBP: hepato-biliary-pancreatic surgery; BS: breast surgery; VS: vascular surgery.

to undergo GI cancer surgery immediately after BAV, the severity of AS deteriorated 2 months after BAV. His AVA decreased from 0.75 cm² 1 day after BAV to 0.66 cm² 2 months after BAV, and he finally underwent laparoscopic sigmoidectomy about 3 months after BAV. We managed to perform this surgery without any complications. In general, restenosis after BAV occurs within 6 months in most patients^[4]. On the other hand, the typical short-term adverse events are tamponade, aortic regurgitation, arrhythmias, hemorrhage of vascular site, and acute kidney injury, all of which occur within 3 days after BAV. Calicchio *et al.* reported that noncardiac surgery was successfully performed within 1 week after BAV^[22]. Taking these reports and our limited experience into account, we suggest that noncardiac surgery should be performed within 1 week to 6 months after BAV.

Finally, while patients who received definitive treatment didn't experience cardiac symptom, 2 out of 5 patients who didn't receive definitive treatment had cardiac symptom or cardiac failure after follow-up. BAV may be effective as a preoperative therapy of noncardiac surgery, but definitive treatment after noncardiac surgery is required if necessary.

This study has several limitations. First, the size of this study was relatively small. Second, most of enrolled patients evaluated here were classified as NYHA Class I or II. Finally, in this study, emergency BAV or GI cancer surgery was excluded. Nevertheless, we believe that our findings will contribute to the optimization of the perioperative strategy for GI cancer surgery in patients with severe AS.

CONCLUSION

We demonstrated the safety and feasibility of BAV as a bridge to noncardiac surgery in patients with severe AS. Gastrointestinal cancer surgery can be performed even in these high-risk patients with the aid of BAV. In high-risk patients, it may be important not only to perform safely intraoperative management but to combine preoperative therapy with surgical treatment.

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