Results of Ten-Year Follow-Up of Alcohol Septal Ablation in Patients with Obstructive Hypertrophic Cardiomyopathy

Maksim Kashtanov¹ Anastasiya Rzhannikova^{1,2} Sergey Chernyshev¹ Lev Kardapol'tsev¹
Eduard Idov^{1,2} Sergey Berdnikov¹

¹Sverdlovsk Regional Hospital No.1, Ekaterinburg, Russia
²Ural State Medical University, Ekaterinburg, Russia

Address for correspondence: Maksim Kashtanov, Sverdlovsk Regional Hospital No.1, Volgogradskaya str. 185, Ekaterinburg, Russia
(e-mail: kashtanov-maksim@mail.ru).

Int J Angiol 2018;27:202–207.

Abstract

This study looks at 10-year follow-up outcomes of alcohol septal ablation in patients with obstructive hypertrophic cardiomyopathy.

Between 2000 and 2008, 40 patients with obstructive hypertrophic cardiomyopathy (27 males, 13 females) underwent alcohol septal ablation. The median follow-up period was 123 (2–179) months. The mean age ran to 43.8 ± 13.9 years. The initial dose of ethanol (3 mL) was chosen for ablation in all cases.

The hospital mortality was 0%. Permanent pacemakers were implanted in 3 of 40 (7.5%) cases in the hospital period. The median clinical follow-up was 123 (2–179) months. Survival rates at 1, 5, 10, and 15 years after the procedure were as follows: 97.5% (95% confidence interval [CI], 95.1–99.9%), 92.5% (95% CI, 94.8–90.2%), 85.0% (95% CI, 82.9–87.1%), and 81.3% (95% CI, 79.3–83.3%), respectively. Seven patients died during follow-up. Sudden death was observed in two cases. Permanent pacemakers were implanted in 2 of 40 (5%) cases in the follow-up. The log-rank test revealed no statistically significant difference between the 15-year survival rate in our cohort and age- and sex-matched general Russian population ($p = 0.11113$).

Alcohol septal ablation provides long-term survival rates that look comparable with age- and sex-matched general population in the 15-year follow-up period.

Keywords

- coronary intervention
- cardiovascular disease
- endovascular procedure
- percutaneous
- intramyocardial
- infarction
- hemodynamics

In 1995, Ulrich Sigwart published the first case of alcohol septal ablation (ASA) in a patient with obstructive hypertrophic cardiomyopathy (HCM).¹ Seven years later, the total number of ASAs performed around the world exceeded that of surgical myectomies (SMs) on record.² However, long-term follow-up data are presently lacking. In the largest Euro-ASA registry, just 212 patients were followed up for more than 10 years.³ de la Torre Hernandez et al provided data about the survival rate after ASA in 45 patients operated at 5 Spanish medical centers with a follow-up period of beyond 10 years.⁴ ►Table 1 gives the number of patients from the longest studies, who underwent ASA and were followed up for more than 10 years.^{3,5,6}

Since 2000, Sverdlovsk Regional Hospital has been performing ASA procedures in patients with obstructive HCM who are refractory to medical treatment. Technical simpli-

city, lesser invasiveness, and easy-to-perform reproducibility of the method have made ASA a first-line therapy in our hospital, thus reducing the number of SMs. Despite its 23-year history, ASA is a relatively young method considered as an alternative to SM. Therefore, we have decided to examine long-term ASA outcomes of patients operated on in our clinic, at least 10 years ago.

Methods

Indications for ASA and Patient Selection

The indications for septal reduction therapy were as follows: New York Heart Association (NYHA) II–IV functional class of heart failure with severe left ventricle outflow tract (LVOT) obstruction and peak gradient (PG) of 50 mm Hg at rest or after exertion. “Exertion” meant a Valsalva maneuver or

Table 1 Number of patients who underwent ASA and were followed more than 10 years in the largest trials

Trial, year of publication [ref.]	Number of patients followed up for more than 10 y
Veselka et al, 2016 ³ (Euro-ASA)	212
Wojtarowicz and Kornacewicz-Jach, 2017 ⁵	23
An et al, 2017 (China) ⁶	29

Abbreviation: ASA, alcohol septal ablation.

physical exercise (20 sit-ups). Patients with concomitant heart disease requiring open surgery were excluded. All patients underwent left heart catheterization and coronary angiography to find the septal branches anatomically “appropriate” for ablation. Criteria for septal arteries “appropriateness” were as follows: the presence of a septal branch (at least 1 mm in diameter) in the proximal part of the left anterior descending (LAD) artery. Anatomical patterns when it was either just one perforator for the whole LAD or a large target septal perforator that supplied blood to the entire length of the interventricular septum (IVS) were excluded, as the risk of an excessive necrosis volume, which could have led to severe arrhythmia disorders over the long term, was high. Age was not considered as a contraindication.

Patients' Characteristics

By the beginning of 2017, our clinic performed 182 ASA procedures on 160 patients with obstructive HCM, refractory to drug therapy. Forty of the 160 patients from this cohort (29 males, 13 females) were followed up for over 10 years (they underwent ASA between 2000 and 2008). The mean age was 43.8 ± 13.9 years. The demographic data of the patients are presented in ►Table 2.

Procedural Details

The procedure was performed using a previously described conventional technique.^{1,7} In all cases, the leads of a temporary transvenous pacemaker were placed in the right ventricular apex for the procedural period and at least 3 days after ASA. After inserting the pacemaker leads, 5,000 units of heparin were administered intravenously. The radial or common femoral arteries were used for arterial access. Note that 6 to 7 F standard guide catheters (Judkins left 4, Amplatz left 2, Extra Back-Up 3,5) were used for left coronary ostium catheterization. Workhorse soft or hydrophilic wires were applied to engage the target septal branch. Over-the-wire balloon catheters 6 to 10 mm long and 1.5 to 2.5 mm in diameter were chosen for occlusion of the target septal branch. Intraoperative transthoracic echocardiography was applied to localize the perfusion zone of the septal branch and to measure the PG noninvasively at rest and after pacing (Brockenbrough–Braunwald–Morrow sign). Also, to assess gradient reduction, invasive hemodynamic monitoring was used. It is a rule that 50% PG reduction should be obtained to inject ethanol. The same dose of ethanol (3 mL) was empirically selected and then intention-

Table 2 Patients' demographic data prior to alcohol septal ablation

Parameter	Value
Family history of sudden cardiac death, <i>n</i> (%)	3 (7.5)
Arterial hypertension, <i>n</i> (%)	13 (32.5)
Ischemic heart disease, <i>n</i> (%)	4 (10.0)
Smoking, <i>n</i> (%)	4 (10.0)
Implanted pacemaker before ASA, <i>n</i> (%)	1 (2.5)
Interventricular septum thickness > 30 mm, <i>n</i> (%)	12 (30)
Previous stenting, <i>n</i> (%)	1 (2.5)
Previous CABG, <i>n</i> (%)	1 (2.5)
Syncope condition, <i>n</i> (%)	5 (12.5)
Previous episodes of ventricular tachycardia, <i>n</i> (%)	2 (5)
Pulmonary lobectomy, <i>n</i> (%)	1 (2.5)
Bronchial asthma, <i>n</i> (%)	1 (2.5)
Right bundle branch block, <i>n</i> (%)	3 (7.5)
Left bundle branch block, <i>n</i> (%)	1 (2.5)
Atrial fibrillation, <i>n</i> (%)	1 (2.5)
HCM SCD risk score	4.4 (1.6–24.5)

Abbreviations: ASA, alcohol septal ablation; CABG, coronary artery bypass grafting; HCM, hypertrophic cardiomyopathy; SCD, sudden cardiac death.

ally used for ablation as the initial dose (no matter the thickness of the septum or perforator) in all cases. At least 5-minute exposure of ethanol was used. The balloon was then deflated and removed. Coronary angiography was done to ensure the septal artery occlusion. Just one septal branch per procedure was ablated in the study. In the case of multiple perforator patterns with crisscross perfusion of the excessive muscular bulge in LVOT, the procedure was performed in a staged fashion (1 septal branch per procedure). After the procedure, the patients were transferred to the intensive care unit. Electrocardiographic (ECG) monitoring was performed for at least 3 days if an atrioventricular conduction was normal. When a complete heart block was observed after ASA, temporary pacing continued for up to 7 days, with consequent decision made on permanent pacemaker implantation. Echocardiography was done on the next day after the procedure and before discharge. Holter monitoring was accomplished 1 day prior to removal of the temporary pacemaker lead.

Patients were followed up 1 year after ASA, then annually with echocardiography, ECG, and Holter monitoring.

Data Collection

Data were obtained from the local database of Sverdlovsk Regional Hospital No.1 and through direct calls to patients or relatives, or their family physician. The Mandatory Health Insurance Fund kindly provided relevant information relating to the long-term survival rate on each patient.

Statistical Analysis

Data were analyzed using IBM SPSS v20.0 and Microsoft Excel 2010 package. Continuous normally distributed data were presented as a mean $\pm$ standard deviation. Continuous non-normally distributed data were given as a median (minimum–maximum). A paired Student's *t*-test was used to compare the two groups with continuous normally distributed data. If the distribution was considered abnormal, a Mann–Whitney U-test was applied. A chi-square test and a Fisher's exact test were done to compare the two groups with categorical data. The analysis of variance with repeated measures (with Bonferroni correction) was performed to compare echocardiographic measures (before ASA, at 1-year follow-up, at last follow-up). To analyze two groups with ordinal data, a Wilcoxon sign test was used. A Kaplan–Meier method was applied to construct survival curves. The survival rate was presented with a 95% confidence interval (CI). The general Russian population death rate was obtained from the sites of the World Health Organization, The Human Mortality Database, and the Federal State Statistics Service (who.int, mortality.org, gks.ru). The method of matching the obtained data with those of the native Russian population was described earlier.⁸ The one-sample log-rank test was done by using an application developed by the Center of Biostatistics, Massachusetts General Hospital (MGH).⁹

Ethics

This study was approved by the local ethical committee of Sverdlovsk Regional Hospital No.1.

Results

Procedural Results

The hospital mortality rate was 0%. Technical success was reached in 97.5% of cases (39/40). Periprocedural complications were as follows: left main dissection, which required emergency coronary artery bypass grafting in 1 patient; and femoral pseudoaneurysm, which was managed by open vascular surgery. Permanent pacemakers were implanted in 3 patients (7.5%).

Long-Term Results

The median clinical follow-up was 123 (2–179) months. The long-term 1-, 5-, 10-, and 15-year survival rates were as follows: 97.5% (95% CI, 95.1–99.9%), 92.5% (95% CI, 94.8–90.2%), 85.0% (95% CI, 82.9–87.1%), and 81.3% (95% CI, 79.3–83.3%), respectively. Sudden death was observed in two cases. Two patients died of ischemic stroke. In three cases, the exact cause of death is still unknown.

In the long-term period, one patient underwent elective percutaneous coronary intervention due to stable angina.

Repeated ASAs were performed in 9 cases: in 7 patients—due to a multiple septal pattern in the proximal part of LAD and crisscross perfusion of the target zone; in 2 cases—because of high bifurcation (it was not possible to place a balloon without coverage of the counter-lateral branch) of the target septal branch, when during the first ASA one subselected branch was ablated and then during

the second stage the counter-lateral branch was also closed. During the long-term follow-up, one patient underwent radiofrequency ablation of the muscular bulge in LVOT. The one sample log rank test did not find any statistical difference in the 15-year survival rate between patients who underwent ASA in our cohort and age- and sex-matched general Russian population ($p = 0.11113$). The standardized mortality ratio was 1.81 (95% CI, 0.79–4.12) (see ►Fig. 1).

Long-Term Rhythm Disorders

A 23-year-old patient (1/40) experienced 4 episodes of sustained ventricular tachycardia registered by his previously implanted permanent pacemaker after 9-year follow-up. The risk of sudden death during the last visit was 16.8% (HCM sudden cardiac death [SCD] risk score). He was referred for implantable cardioverter-defibrillator (ICD) implantation.

In the long-term period, permanent pacemakers were implanted in two patients due to high-grade atrioventricular block 9 and 11 years after ASA. In the follow-up period, 5 patients experienced new-onset atrial fibrillation (AF) (2 permanent cases and 3 paroxysmal ones), with 1 patient showing permanent AF at baseline.

Treatment Effect

PG at rest and after exertion significantly decreased as compared with its values after 1- and 10-year follow-ups (resting PG at baseline vs. resting PG 1 year after, $p < 0.0001$; resting PG at baseline vs. resting PG 10 years after, $p < 0.0001$; exertional PG at baseline vs. exertional PG 1 year after, $p < 0.0001$; exertional PG at baseline vs. exertional PG 10 years after, $p < 0.0001$) (see ►Table 3). At the same time, there were no statistical differences between the gradients at 1- and 10-year follow-ups (resting PG 1 year after vs. resting PG 10 years after, $p = 0.908$; exertional PG 1 year after vs. exertional PG 10 years after, $p = 0.531$). IVS thickness at the target zone decreased significantly after 1 year and after 10 years (IVS before ASA vs. IVS 1 year after, $p < 0.0001$; IVS before ASA vs. IVS 10 years after, $p < 0.0001$; IVS 1 year after vs. IVS 10 years after, $p < 0.0001$). During the follow-up period, the ejection fraction and left atrium diameter values were stable (without statistically significant changes as compared with baseline ones, $p > 0.05$). End-diastolic diameter (EDD) did not change between the baseline and 1 year after ASA ($p > 0.05$), but a negative trend toward the enlargement of EDD was observed between the 1- and 10-year time periods (EDD 1 year after vs. EDD 10 years after, $p = 0.033$; EDD before ASA vs. EDD 10 years after, $p = 0.035$).

The heart failure severity (NYHA class) before ASA and 1 year after decreased, but the NYHA functional class remained practically the same between 1- and 10-year follow-ups (before ASA vs. 1 year after, $p < 0.0001$; before ASA vs. 10 years after, $p < 0.0001$; 1 year after vs. 10 years after, $p > 0.05$).

The Canadian Cardiovascular Society functional class of angina pectoris also statistically did not differ between the baseline values and those after 1 year ($p > 0.05$) and 10 years ($p > 0.05$).

Fig. 1 Survival after alcohol septal ablation (ASA) versus age- and sex-matched general population survival.

Table 3 Dynamics of echocardiographic variables and clinical characteristics before intervention, 1 year after, and 10 years after

Indicator	Before intervention	1 y after	10 y after	Before intervention vs. 1 y after	Before intervention vs. 10 y after	1 y after vs. 10 y after
Peak gradient at rest, mm Hg	49 (19–150) ^a	17 (6–50) ^a	16 (2–70) ^a	$p < 0.0001$	$p < 0.0001$	$p > 0.05$
Peak gradient after exertion, mm Hg	113 (47–250) ^a	38 (10–93) ^a	29 (10–110) ^a	$p < 0.0001$	$p < 0.0001$	$p > 0.05$
Ejection fraction, %	0.71 ± 0.09	0.70 ± 0.10	0.70 ± 0.12	$p > 0.05$	$p > 0.05$	$p > 0.05$
Left atrium, mm	44.5 ± 7.2	44.4 ± 7.7	45.4 ± 7.9	$p > 0.05$	$p > 0.05$	$p > 0.05$
Interventricular septum, mm	26.6 ± 5.5	22.8 ± 6.0	20.6 ± 5.4	$p < 0.0001$	$p < 0.0001$	$p < 0.0001$
End-diastolic dimension, mm	42.4 ± 4.9	43.7 ± 5.5	44.8 ± 6.0	$p > 0.05$	$p = 0.035$	$p = 0.033$
NYHA class, n (%)	1	2 (5)	17 (42.5)	$p < 0.0001$	$p < 0.0001$	$p > 0.05$
	2	12 (30)	21 (52.5)			
	3	24 (60)	2 (5)			
	4	2 (5)	0			
CCS class, n (%)	0	27 (67.5)	29 (72.5)	$p > 0.05$	$p > 0.05$	$p > 0.05$
	1	5 (12.5)	8 (20.0)			
	2	7 (17.5)	3 (7.5)			
	3	1 (2.5)	0			
	4	0	0			

Abbreviations: ANOVA, analysis of variance; CCS, Canadian Cardiovascular Society; NYHA, New York Heart Association.

^aGiven abnormal distribution of data obtained, their logs were taken to compare them by analyzing the variables of ANOVA with repeated measures. The normality of logs distribution of the variables was then confirmed.

Five patients had initial syncopal episodes, 1 experienced syncope in 1 year, and 2 patients at 10-year follow-up.

The HCM SCD risk score statistically significantly decreased (4.4 [1.6–24.5]% vs. 2.3 [1.2–13.9]%, $p < 0.0001$) during the long-term follow-up.

Discussion

Ten-Year Survival following ASA

In 2016, Veselka et al published the long-term results of ASA from the largest Euro-ASA registry, which included 1,275 patients. Survival rates at 1, 5, and 10 years after ASA were 98% (95% CI, 96–98), 89% (95% CI, 87–91%), and 77% (95% CI, 73–80%), respectively.³ In our cohort, 1-, 5-, 10-, and 15-year survival rates accounted for 97.5% (95% CI, 95.1–99.9%), 92.5% (95% CI, 94.8–90.2%), 85.0% (95% CI, 82.9–87.1%), and 81.3% (95% CI, 79.3–83.3%). However, our patients were younger (58 ± 14 years [the Euro-ASA group] vs. 43.8 ± 13.9 [our cohort]), this feature might explain the difference.

Sudden Death Risk and ASA Outcomes

In our study, the median of baseline 5-year SCD risk was 4.4 (1.6–24.5)% as assessed by the HCM SCD risk score model. At the same time, 12 patients had a high initial risk of SCD (more than 6%). This high value can be explained by the fact that the model was given in the guidelines of the European Society of Cardiology in 2014 and ASAs in our cohort were performed between 2000 and 2008.

Just one patient in our cohort underwent ICD implantation. The HCM SCD risk score model was not initially recommended for use in case of myectomy or ASA, but it was recently validated for a population of patients undergoing septal reduction therapy.¹⁰ After ASA, we found a statistically significant decline of SCD risk down to 2.3 (1.2–13.9)% ($p < 0.0001$). Despite the fact that SCD risk was still high, excessive annual mortality was not registered in the 15-year follow-up period (in our experience it was 0.7%/year).

Ethanol Dose

One of the key features of our experience is the use of the same dose of ethanol in all cases (3 mL). In case of multiple septal pattern with crisscross blood supply to the excessive muscular LVOT bulge, ASA procedures were performed in a staged fashion (1 branch per procedure). This strategy was chosen empirically. Subsequently, when analyzing the data of the largest North American ASA register, one-stage ablation of several septal branches was identified as an independent predictor of mortality.¹¹

There are two rules for selecting the dose of ethanol: (1) it should be based either on the septum thickness or (2) on the perforator's diameter.⁷ However, the basis of such strategies is expert opinion, and not the evidence. Also, the dose selection strategy (based either on IVS thickness, or septal branch thickness, or one and the same dose) was not tested in various studies (where just groups with different doses of ethanol were compared).^{12,13}

Generally, during ASA the ethanol dose is selected irrelevant to the volume of the perforator's vascular bed. In the

literature, there is no obvious evidence about the necessity of a complete septal artery closure after ethanol injection. And if a need arises to do so, we still do not know which dose, perforator's diameter (or vascular bed) and speed of injection, is adequate to close it with 100% confidence.

In our cohort, two patients with incomplete septal occlusions suffered from residual obstruction, and they had to undergo successful repeated ablation. This problem arouses some controversy. On the one hand, a few authors demonstrated that a low ethanol dose (1–2 mL) was associated with the same reduction of LVOT obstruction.^{12,13} Obviously, a higher dose of ethanol leads to more radical elimination of obstruction. However, the upper limit of the safe dose is not well established (dedicated randomized trial was not done). Recently, Veselka et al identified a dose of 1.5 to 2.5 mL as well-balanced in terms of safety and efficiency based on the data from Euro-ASA registry.³

We empirically selected a 3-mL dose as the best compromise between the hemodynamical effect and the ability to close the perforator completely, and it was chosen as the universal initial dose.

Comparison with General Age- and Sex-Matched Russian Population

Comparing the long-term outcomes of interventions with those of general age- and sex-matched general population is a current typical technique used in observational studies. This technique was described in detail by Finkelstein et al.⁸ Since the one-sample log-rank test is often not presented in popular statistical packages, the Centre of Biostatistics in MGH developed a special free Microsoft Excel application, which included the test itself and also data on the U.S. population as a control. To compare our cohort with the Russian population, the “death rate” values of the U.S. population were substituted with appropriate Russian values taken from the World Health Organization (www.who.int), Russian Federal State Statistic Service (gks.ru), and Human Mortality Database (mortality.org) sites.

A similar comparison was made by Veselka et al in 2014 for 178 patients with a follow-up period of 4.8 (interquartile range [IQR], 2.1–7.5) years. Age- and sex-matched survival rates between the groups were not statistically different.¹⁴ Sorajja et al from Mayo Clinic also demonstrated comparable survival rates of patients who underwent ASA with expected survival in the natural population of the United States ($p = 0.64$); the median follow-up was 5.7 years (maximum 11.9 years).¹⁵ Jensen et al also showed that the survival rate of patients after ASA did not statistically differ significantly ($p = 0.06$) from that of the general population of Denmark during the follow-up period 3.7 (IQR, 1.4–6.3) years.¹⁶

We intentionally examined a cohort of patients who had been operated on at least 10 years before to be able to evaluate the patients' 15-year survival function after ASA, given the lack of long-term data. The median follow-up period was 123 (2–179) months.

The one-sample log-rank test did not find statistically significant differences between the 15-year survival rates in

our cohort and the age- and sex-matched general Russian population ($p = 0.11113$).

Limitations

This is a retrospective observational study with inherent limitations of this type of studies. Taking into account a small cohort of patients, the findings from the statistical analysis cannot be extrapolated to other patient populations but may prove promising for further research.

Conclusions

ASA is safe and efficient during a 15-year follow-up period. Alcohol septal ablation provides long-term survival rates that look comparable with those typical of age- and sex-matched general population.

Acknowledgment

The authors would like to express their gratitude to Vladimir F. Kochmashev for high-quality statistical processing of data.

References

- 1 Sigwart U. Non-surgical myocardial reduction for hypertrophic obstructive cardiomyopathy. *Lancet* 1995;346(8969):211–214
- 2 Maron BJ, Yacoub M, Dearani JA. Controversies in cardiovascular medicine. Benefits of surgery in obstructive hypertrophic cardiomyopathy: bring septal myectomy back for European patients. *Eur Heart J* 2011;32(9):1055–1058
- 3 Veselka J, Jensen MK, Liebrechts M, et al. Long-term clinical outcome after alcohol septal ablation for obstructive hypertrophic cardiomyopathy: results from the Euro-ASA registry. *Eur Heart J* 2016;37(19):1517–1523
- 4 de la Torre Hernandez JM, Masotti Centol M, Lerena Saenz P, et al. Effectiveness and safety beyond 10 years of percutaneous transluminal septal ablation in hypertrophic obstructive cardiomyopathy. *Rev Esp Cardiol (Engl Ed)* 2014;67(05):353–358
- 5 Wojtarowicz A, Kornacewicz-Jach Z. Alcohol septal ablation in hypertrophic cardiomyopathy utilizing a longitudinal 17-year study (mean 10.8). Observation follow-ups taken at a single medical centre. *Cardiol J* 2017;24(02):125–130
- 6 An SY, Yang YJ, Hang F, Wang ZM, Fan CM. Procedural complication and long term outcomes after alcohol septal ablation in patients with obstructive hypertrophic cardiomyopathy: data from China. *Sci Rep* 2017;7(01):9506
- 7 Cuisset T, Lefèvre T. Contemporary techniques for catheter-based intervention for hypertrophic obstructive cardiomyopathy. *Euro-Intervention* 2016;12:X44–X47
- 8 Finkelstein DM, Muzikansky A, Schoenfeld DA. Comparing survival of a sample to that of a standard population. *J Natl Cancer Inst* 2003;95(19):1434–1439
- 9 Massachusetts General Hospital (MGH). MGH Biostatistics. Available at: <http://biostatistics.mgh.harvard.edu/biostatistics/resources.html>. Accessed September 28, 2018
- 10 Liebrechts M, Faber L, Jensen MK, et al. Validation of the HCM Risk-SCD model in patients with hypertrophic cardiomyopathy following alcohol septal ablation. *Europace* 2018Sep 1;20(F12):f198–f203
- 11 Nagueh SF, Groves BM, Schwartz L, et al. Alcohol septal ablation for the treatment of hypertrophic obstructive cardiomyopathy. A multicenter North American registry. *J Am Coll Cardiol* 2011;58(22):2322–2328
- 12 Veselka J, Tomašov P, Zemánek D. Long-term effects of varying alcohol dosing in percutaneous septal ablation for obstructive hypertrophic cardiomyopathy: a randomized study with a follow-up up to 11 years. *Can J Cardiol* 2011;27(06):763–767
- 13 Kuhn H, Lawrenz T, Lieder F, et al. Survival after transcatheter ablation of septal hypertrophy in hypertrophic obstructive cardiomyopathy (TASH): a 10 year experience. *Clin Res Cardiol* 2008; 97(04):234–243
- 14 Veselka J, Krejčí J, Tomašov P, Zemánek D. Long-term survival after alcohol septal ablation for hypertrophic obstructive cardiomyopathy: a comparison with general population. *Eur Heart J* 2014;35(30):2040–2045
- 15 Sorajja P, Ommen SR, Holmes DR Jr, et al. Survival after alcohol septal ablation for obstructive hypertrophic cardiomyopathy. *Circulation* 2012;126(20):2374–2380
- 16 Jensen MK, Almaas VM, Jacobsson L, et al. Long-term outcome of percutaneous transluminal septal myocardial ablation in hypertrophic obstructive cardiomyopathy: a Scandinavian multicenter study. *Circ Cardiovasc Interv* 2011;4(03):256–265