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Review Article

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The left ventricular outflow tract – How surgery for hypertrophic cardiomyopathy is changing?

Abstract

The gold standard in the treatment of hypertrophic obstructive cardiomyopathy is transaortic surgical myectomy, a technique with a proven 60-year track record, which eliminates obstruction and improves symptoms and, therefore, functional capacity and with established cost-effectiveness. Newer pharmacological agents such as myosin inhibitors are now being tested in clinical practice. A surgical alternative has recently been introduced, transapical beating-heart septal myectomy. This approach has the same goals as transaortic myectomy and offers additional advantages such as its minimally invasive nature, as no cardiopulmonary bypass and cardiac arrest are needed, together with a real-time assessment of resection with intraoperative transoesophageal echocardiography. Patients with an appropriate indication for septal myectomy will benefit from this newly introduced procedure.

Keywords: Hypertrophic obstructive cardiomyopathy, septal reduction therapy, transaortic septal myectomy, transapical beating heart septal myectomy

INTRODUCTION

There is general agreement that surgery is the gold standard of therapy in patients with symptomatic left ventricular outflow obstruction (LVOTO) (1). Surgical myectomy (SM) is an old operation with a proven six-decade track record of improvement in the quality of life in patients in the setting of hypertrophic cardiomyopathy (HOCM) (2-5).

Having said that, there are still in 2025 some gaps in knowledge and practice that need to be addressed. There are no randomized controlled trials (RCT) between SM and other established and developing septal reduction therapies (SRT) such as alcohol septal ablation (ASA) and, more recently, cardiac myosin inhibitors (CMI) (6-10). Furthermore, there are many practices of SRT including SM around the world (11). Scientific evidence on SM comes from a few high-volume centres (12-14) and it is also clear that there are biased practices, with specific preference to less invasive SRTs over SM (15,16).

This contribution aims at producing an overview of the situation of SRT including SM in current times, to highlight the prominent role of SM considering its excellent long-term outcomes in patients with LVOTO and to identify future directions in the surgical treatment of HOCM.

Methods

Study design

This is a narrative review summarizing essential aspects of the surgery for HOCM, with focus on the evolution of therapy over time and identifying future alternative surgical approaches. It is structured in a way that they are all individually identified.

Ethics

This is a literature review with no direct information retrieved from actual patients; therefore, it does not need ethical clearance from the Ethics Committee/Institutional Review Board. In this line, no written informed consent is necessary as no patients or hospital files have been individually addressed.

Literature search

The following terms were used to interrogate the free engine search PubMed that primarily accesses the MEDLINE database [Medline access]: "Hypertrophic obstructive cardiomyopathy" "Surgery" "Septal reduction therapy" and "Follow-up". Articles were selected based on its relevance to the topic regardless of the year of publication but with focus on those published in the past 5 years.

Lines of Treatment in HCOM (Until now)

Since the initial description of the disease (17,18) and the first attempts to perform SM (2,19), the initial line of treatment for patients with HCM with and without LVOT is medical treatment (20). Septal myectomys is considered the best treatment in HOCM (21) and ASA is the currently accepted major alternative to surgery. Very recently, myosin modulation has emerged as an expected efficient therapy that might improve or even cure a large proportion of patients suffering of HCM including those with LVOTO (22). Two molecules, mavacamten and aficamten -the latter commercially available in the USA- are, at the time of writing, approved for clinical use and are expected to have a bright commercial future despite the extremely associated high costs (10,23,24). Finally, heart transplantation is the last resort in patients with HOCM deemed not amenable or unfit for classical SM (25).

Factors Influencing the Choice of Therapy

There are multiple factors which have an impact on therapy will be delivered. The balance between a given SRT, be ASA or SM is frequently not easy or is simply biased in the case of patients with LVOTO. Age, symptoms, septal anatomy, the first septal perforator artery, comorbidity and frailty, pre-existing conduction abnormalities, concomitant coronary artery disease are to be considered. The same applies to the experience in the catheterization laboratory or that of the surgical team. Medication, expected lifesyle and patient preference also play a role in the dcision-making process.

The Gold Standard

As consistently repeated in the literature and as said above, SM is the gold standard due to its very long track record of efficacy and efficiency. It is a one-time low operative risk, has a low risk of permanent pacemaker implantation and reoperation, can be offered at all ages and disease phenotypes (26) and provides maximum improvement in the quality of life (QOL) and exercise capacity, allowing for the removal of negative inotropic agents. With regards to anatomy, it is of utmost importance to understand the specifics of every phenotype that can benefit from surgery. The sketches show the obstructive basal phenotype, Zone I, that is accompanied by mitral regurgitation (Figure 1a, b). The second major phenotype, the midventricular, Zone II, phenotype is also related to mitral regurgitation (Figure 2a, b). Furthermore, it is a very cheap cardiac operation among other reasons because no intracardiac foreign material is required and left inside a heart chamber (21,22).

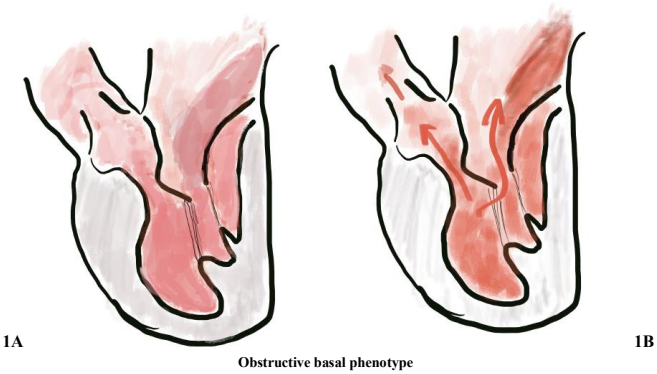

Figure 1. A. Sketches shows the basal obstructive phenotype; **B.** Mitral regurgitation due to systolic anterior motion of the mitral valve

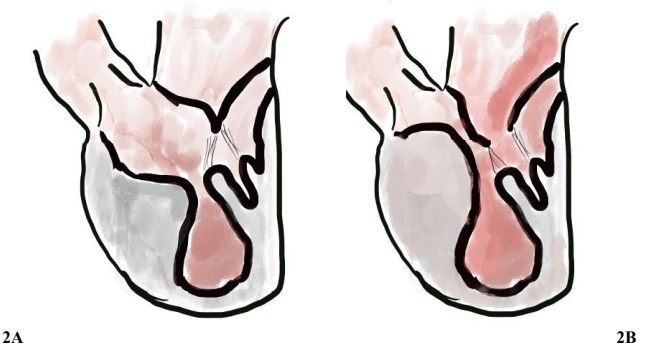

Figure 2. A. Pure midventricular obstruction without systolic anterior motion of the mitral valve (SAM); **B.** Combined basal and midventricular obstruction with SAM and secondary mitral regurgitation

Septal Reduction Therapy

Alcohol septal ablation

Over the past 25 years, ASA has been increasingly used to treat HOCM patients and has become the primary SRT in Europe (6,7). When using ASA there is no discrimination across the board although some indications seem to prevail (21). Today, a quarter of century later, there is also agreement within the community that SM is superior although some may argue outcomes and mortality rates were similar (4,5).

A key question when ASA is discussed, is that tissue reaction to alcohol is simply random (27). When injecting alcohol there is no discrimination and the target tissue may be larger than expected with unknown consequences despite some may confirm that the outcomes are appropriate. Further, there are no randomized trials comparing ASA and SM and it is doubtful that there will ever be as it has been addressed in the past (9).

The LVOT gradient and LA pressures improve acutely with ASA. However, for an effective ASA there are strict criteria such as advanced NYHA class (III-IV) with refractory symptoms and LVOTO>50 mmHg, absence of mitral valve disease and suitable coronary arteries (28) maeaning favorable anatomy without coexisting surgically amenable disease. Septal thickness might have negative input on follow-up survival (29).

Residual obstruction after ASA must be taken seriously as it is associated with cardiovascular mortality events (30). Temporal conduction disturbances are the most common complications after ASA and atrioventricular block and the need for permanent pacemaker implantation after ASA may average up to 18% in the first 72 hours after the procedure (31,32). And up to 10-20% may present also on a delayed basis. On the other hand, SM for LVOTO with symptoms is associated with a marked reduction in the incidence of appropriate ICD discharge and risk for SCD (33).

Alcohol septal ablation and SM have different survival. Data from large-volume centres confirm that the 10-year all-cause mortality was higher in ASA than in SM patients before and after adjustment for age, sex, and comorbidities (5). The key issue, in any case, is the appropriate selection of patiens for each SRT option.

Challenging alternatives to ASA

Although ASA has been in clinical practice for three decades now (34) and has specific restrictive indications, there are some percutaneous alternatives that aimed at challenging this approach. Coil embolization of septal artery was attempted, and its clinical efficacy and safety assessed in small series but without actual follow-up (35,36).

Non-alcohol agents are supposed to have advantages over alcohol and copolymers have been used for septal ablation. The scanty experience reported included the lack of reduction in LVOT gradient in 10-15%. Follow-up was restricted to 12 months in small series (37). The same can be said about microsphere embolization of septal artery, as there is little experience with very short follow-up shorter than 6 months (38). Cyanoacrylate seems to be superior to ASA due to its immediate polymerization preventing the leak into the left anterior descending coronary artery (39,40). All such studies claim effectiveness and safety of the technique without significant procedural complications.

More recently the feasibility and safety of the emerging percutaneous intramyocardial septal radiofrequency ablation (PIMSRA) has been described in a large patient cohort with drug-refractory HOCM. A single-arm, open-label study from China in 200 young patients (46.9±14.0 years), confirmed reduction of maximum septal thickness and left ventricular outflow tract gradients and 96% of them were in New York Heart Association functional class I or II at last follow-up. This procedure may be effective for relief of LVOTO with acceptable complication rates (41,42) and it is being currently expanded to non-obstructive forms of HOCM (43). It may represent an alternative to ASA but comparative studies are lacking.

Where are We? Surgical Myectomy

Although SM and ASA evolved head-to-head, after the introduction in clinical practice of the latter, collected data confirmed that SM has more anatomic and clinical advantages than ASA that include immediate relief of obstruction, the ability to address abnormalities of the mitral valve and other lesions requiring surgical treatment. Septal myectomy can address the extremely thick septum. It has a long-proven efficacy, can be performed in adults and children and leaves no myocardial scar. All this has been confirmed on meta-analysis (44). Data from this meta-analysis incorporating 2791 SM and 2013 ASA patients confirmed statistically significant differences with higher PPM, total adverse arrhythmic events and reoperation rates in the ASA patients.

The selection criteria for both SRT are not the same. The main differences are outlined in Table 1 (41). The patient profile is restricted in the case of ASA and SM, regardless of its beneficial effects over time, is a more versatile therapy as this operation addresses all septal thicknesses and the surgeon will be able to tackle mitral valve complex abnormalities and LVH from the basal to the apical segments.

Table 1. Selection criteria in hypertrophic cardiomyopathy

	Alcohol septal ablation	Septal myectomy
LV wall thickness	<25	<18
Extent of hypertrophy	Basal only	Basal, midventricular Apical, right ventricular
Mitral valve	Normal	Abnormalities present
Septal branch	Required	Not critical

Adapted from Mestres et al. (Ref 21)

The effectiveness and risks of SM have been well established in the literature. The regression of the LV thickness and the peak LVOT gradients are persistently low over the first 10 years after surgery and beyond. In-hospital mortality in large-volume centres is very low <1% as has been confirmed by the HCM Consortium data from 10 Institutions worldwide (45,46). Even in the controversial population of those aged >65 years, surgical outcomes including all major SM-related complications are low and persistently good at five postoperative years (47,48).

What Comes Next?

The discussion will go on. As discussed, SM is the gold standard and ASA has been predominantly spread as a primary SRT especially in Europe, which leaves a proportion of patients untreated or receiving suboptimal therapy according to the intrinsic characteristics of the patient. Medical therapy has received a boost with the introduction of cardiac myosin inhibitors as a novel treatment option (49). Currently, the two accepted drugs, mavacamten and aficamten are competing for the huge market that can easily be estimated in USD. A variety of clinical trials mavacamten-based (50-52) or aficamten-based (53,54) exploring diverse endpoints like clinical and hemodynamic improvement or cardiac remodeling with still very short follow-up are being completed but no current comparisons with the gold standard SM are to be performed for a variety of reasons.

Despite all these recent trials, the community should not forget that SM produces an unmatched gain in Kansas City Cardiomyopathy Questionnaire (KCCQ) and quality of life (QoL) as perfectly documented in the literature (55,56). Furthermore, and despite being iterative, the optimal timing for surgery depends on symptoms and, in the asymptomatic patient, on a variety of conditions that are summarized in Table 2.

Table 2. The optimal timing for surgery

Any symptoms (even mild) in the presence of severe obstruction (>50 mmHg)
Asymptomatic patients with severe obstruction (with absence of right bundle branch block), with any
Very high gradients > 100 mmHg
Evidence of LA enlargement
Evidence of pulmonary hypertension
Family history of sudden death
Signs of mitral valve degeneration (leaflet thickening)
Very young and low-risk candidates

Moreover, there are currently advancements in the surgical strategy and instrumentation. After a feasibility study in swine (57), transapical beating-heart septal myectomy (TA-BSM) was introduced in clinical practice as recently as in 2023 with the report of 47 patients (58). This novel approach to the operative treatment of HOCM is founded on reducing the surgical trauma by reducing the access performing a small anterior thoracotomy and avoiding cardiopulmonary bypass. Myectomy is performed using a specifically designed surgical instrument, the BMD device (Wuhan Weixintan Medical Technology Co Ltd, Wuhan, PRC) constructed with a bullet-headed resection tube and a multifunctional handle (Figure 3). Figure 4 shows the operative field in the pig model and a resected specimen in comparison with the device and the surgeons' hand. Clinical experience is still restricted to the pioneering team at Wuhan Tongji Hospital and a RCT is underway in China, which will provide useful information for widespread utilization of this operation.

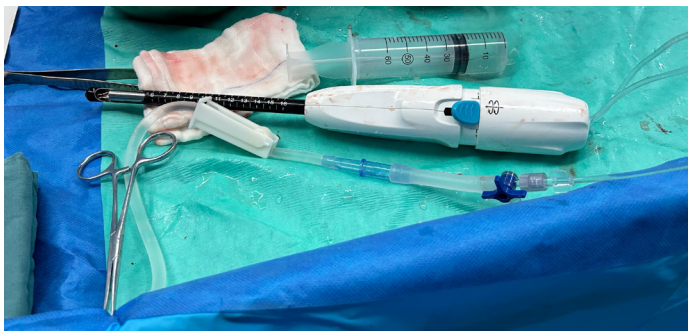

Figure 3. The BMD device (Wuhan Weixintan Medical Technology Co Ltd, Wuhan, PRC) constructed with a bullet-headed resection tube and a multifunctional handle, for transapical insertion

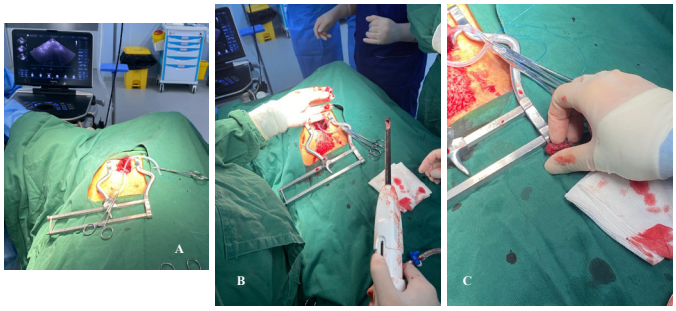

Figure 4. A. Operative field, anterior thoracotomy, in the pig; **B.** The device and the surgeon holding a resected muscle specimen; **C.** Comparison of the resected specimen and the surgeon's hand

In the meantime, institutional experience is growing and TA-BSM is being analyzed on a 360° perspective. Coronary microvascular dysfunction is a pathophysiological mechanism underlying HOCM and cardiac magnetic resonance (CMR) shows that in both hypertrophic and non-hypertrophic myocardial segments microvascular dysfunction was improved in patients after TA-BSM (59). In addition, CMR has also confirmed confirmed early reverse remodeling of left heart morphology and function in these HOCM patients following TA-BSM (60).

As TA-BSM is an innovative approach which aims at reducing trauma and increasing the pool of patients who will benefit from septal reduction, important aspects of the operation need to be clarified. Among them, how reproducible the technique is and how steep the learning process could be. A recent study on a consecutive series of 177 patients established that competence in TA-BSM was achieved after 44 cases, without negative impact on guideline-desired outcomes. This early data support the belief that this new technique may represent an option for wider dissemination of HOCM surgery worldwide and improve disease management (61). And more recently, the analysis of a larger series of 418 patients has proven that with real-time transesophageal intraoperative echocardiographic guidance, the individualized TA-BSM approach can effectively and safely achieve adequate and precise muscle resections (Figure 5). Awaiting for the results of the abovementioned chinese RCT, TA-BSM potentially broadens the applicability of surgical SRT in the treatment of HOCM (62).

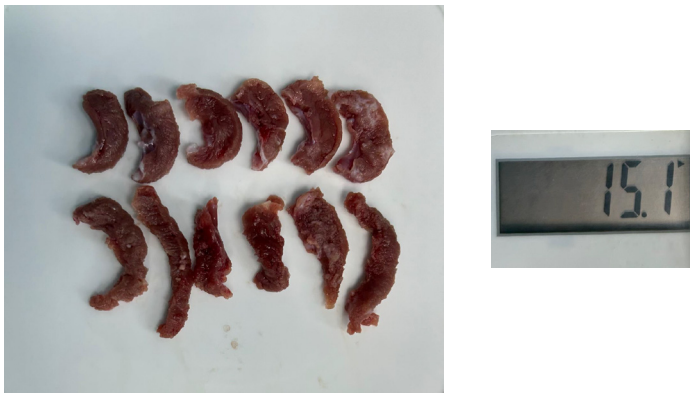

Figure 5. Human resected specimens totalling a weight of 15. 1 g

CONCLUSION

The analysis of the accumulated information on SM and ASA, and considering the emergence of medical therapy with oral myosin inhibitors and the surgical innovation represented by TA-BSM, some conclusions can be drawn:

1. Septal myectomy stood the test of time over 60 years,

2. Septal myectomy is one of the safest open-heart procedures with a very low mortality 0.3 – 0.5% (<1%),

3. Septal myectomy abolishes obstruction,

4. There is lower risk of PPM requirements and its consequences in comparison with ASA,

5. Septal myectomy is a potentially curative operation,

6. Therapy with myosin inhibitors needs to pass the test of time and sustain the potential impact of an RCT for comparisons with SM,

7. Septal myectomy is the "gold standard" for obstruction relief in HCM,

8. Transapical beating-heart myectomy will be disruptive.

Conflict of Interests: The authors declare that there are no conflict of interests.

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REFERENCES

1. Mestres CA, Bartel T, Sorgente A, Müller S, Gruner C, Dearani J, et al. Hypertrophic obstructive cardiomyopathy: what, when, why, for whom?. Eur J Cardiothorac Surg. 2018; 53:700-7.
2. Morrow AG, Brockenbrough EC. Surgical treatment of idiopathic hypertrophic subaortic stenosis: technic and hemodynamic results of subaortic ventriculomyotomy. Ann Surg. 1961;154:181-9.
3. Maron MS, Rosing DR, Braunwald E, Rastegar H, Koethe B, Roberts WC, et al. Sixty-year evolution of surgical myectomy for symptomatic obstructive hypertrophic cardiomyopathy with insights from the historic NIH surgical experience to present . Am J Cardiol. 2022;172:107-8.
4. Ommen SR, Maron BJ, Olivotto I, Maron MS, Cecchi F, Betocchi S, et al. Long-term effects of surgical septal myectomy on survival in patients with obstructive hypertrophic cardiomyopathy. J Am Coll Cardiol. 2005;46:470-6.
5. Cui H, Schaff HV, Wang S, Lahr BD, Rowin EJ, Rastegar H, et al. Survival following alcohol septal ablation or septal myectomy for patients with obstructive hypertrophic cardiomyopathy. J Am Coll Cardiol. 2022;79:1647-55.
6. Martin WA, Sigwart U. Who and how to treat with non-surgical myocardial reduction therapy in hypertrophic cardiomyopathy: long-term outcomes. Heart Fail Monit. 2002;3:15-27.
7. Buell HE, Stables RH, DeLong ER, Shuping KB, Killip DM, Lever HM, et al. Percutaneous transluminal septal reduction for hypertrophic obstructive cardiomyopathy: report from an international pilot study. J Med Syst. 2002;26:293-300.
8. Achim A, Serban AM, Mot SDC, Leibundgut G, Marc M, Sigwart U. Alcohol septal ablation in hypertrophic cardiomyopathy: For which patients?. ESC Heart Fail. 2023;10:1570-9.
9. Olivotto I, Ommen SR, Maron MS, Cecchi F, Maron BJ. Surgical myectomy versus alcohol septal ablation for obstructive hypertrophic cardiomyopathy. Will there ever be a randomized trial?. J Am Coll Cardiol. 2007;50:831-4.
10. Quintana E, Bajona P, Myers PO. Mavacamten for hypertrophic obstructive cardiomyopathy. Lancet. 2021;397:369.
11. 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;32:1055-8.
12. Geske JB, Schaff HV. Role of experience in myectomy for hypertrophic cardiomyopathy: with very high procedural volume, myectomy remains low-risk even with concomitant procedure need. Int J Cardiol. 2024;404:131961.
13. Ommen SR, Nishimura RA, Schaff HV, Dearani JA. Hypertrophic cardiomyopathy: state of the art. Mayo Clin Proc. 2025;100:557-66.
14. Holst KA, Schaff HV, Smedira NG, Habermann EB, Day CN, Badhwar V, et al. Impact of hospital volume on outcomes of septal myectomy for hypertrophic cardiomyopathy. Ann Thorac Surg. 2022;114:2131-8.
15. Maron MS, Olivotto I, van Sinttruije M. A plain language summary of the SEQUOIA-HCM study: aficamten for symptomatic obstructive hypertrophic cardiomyopathy. Future Cardiol. 2025;21:415-32.
16. Davis BJ, Volk H, Nguyen O, Kamna D, Chen H, Barriales-Villa R. Safety and efficacy of mavacamten and aficamten in patients with hypertrophic cardiomyopathy. J Am Heart Assoc. 2025;14:e038758.
17. Goodwin JF, Hollman A, Cleland WP, Teare D. Obstructive cardiomyopathy simulating aortic stenosis. Br Heart J. 1960;22:403-14.
18. Braunwald E, Brockenbrough EC, Morrow AG. Hypertrophic subaortic stenosis--a broadened concept. Circulation. 1962;26:161-5.

19. Kirklin JW, Ellis FH Jr. Surgical relief of diffuse subvalvular aortic stenosis. Circulation. 1961;24:739-42.

20. Awad K, Pereyra M, Farina JM, Pathangey G, Abbas MT, Scalia IG, et al. Efficacy of pharmacological therapies in reducing outflow tract obstruction in patients with obstructive hypertrophic cardiomyopathy: a systematic review and meta-analysis. Eur Heart J Cardiovasc Pharmacother. 2025:pvaf036. doi: 10.1093/ehjcvp/pvaf036. Epub ahead of print.

21. Mestres CA, Bartel T, Sorgente A, Müller S, Gruner C, Dearani J, et al. Hypertrophic obstructive cardiomyopathy: what, when, why, for whom?. Eur J Cardiothorac Surg. 2018;53:700-7.

22. Ogurek I, Gill R, Tasouli-Drakou V, Joseph R, Khalid A, Houshmand N, Tak T. A Narrative review of current and investigational therapies in hypertrophic cardiomyopathy. Biomedicines. 2025;13:1327.

23. Olivotto I, Oreziak A, Barriales-Villa R, Abraham TP, Masri A, Garcia-Pavia P, et al.; EXPLORER-HCM study investigators. Mavacamten for treatment of symptomatic obstructive hypertrophic cardiomyopathy (EXPLORER-HCM): a randomised, double-blind, placebo-controlled, phase 3 trial. Lancet. 2020;396:759-69. Erratum in: Lancet. 2020;396:758.

24. Saberi S, Abraham TP, Choudhury L, Barriales-Villa R, Elliott PM, Nassif ME, et al.; FOREST-HCM Steering Committee and Investigators. Aficamten treatment for symptomatic obstructive hypertrophic cardiomyopathy: 48-week results from FOREST-HCM. JACC Heart Fail. 2025;13:102496.

25. Mazur M, Bhat G, Popjes E, Dowling R, Eisen HJ. Long-term post-transplantation outcomes in patients with hypertrophic cardiomyopathy: Single-center 35-year experience. Clin Transplant. 2024;38:e15265.

26. Quintana E, Johnson JN, Sabate Rotes A, Cetta F, Ommen SR, Schaff HV, et al. Surgery for biventricular obstruction in hypertrophic cardiomyopathy in children and young adults: technique and outcomes. Eur J Cardiothorac Surg. 2015;47:1006-12.

27. Raute-Kreinsen U. Morphology of necrosis and repair after transcoronary ethanol ablation of septal hypertrophy. Pathol Res Pract. 2003;199:121-7.

28. Alabdaljabar MS, Cendrowski EE, Nishimura RA, Miranda WR, Geske JB, Rihal CS, et al. Hemodynamic predictors of outcome following alcohol septal ablation for hypertrophic obstructive cardiomyopathy. Circ Cardiovasc Interv. 2023;16:e013068.

29. Lu M, Du H, Gao Z, Song L, Cheng H, Zhang Y, et al. Predictors of outcome after alcohol septal ablation for hypertrophic obstructive cardiomyopathy: an echocardiography and cardiovascular magnetic resonance imaging study. Circ Cardiovasc Interv. 2016;9:e002675.

30. Veselka J, Tomašov P, Januška J, Krejčí J, Adlová R. Obstruction after alcohol septal ablation is associated with cardiovascular mortality events. Heart. 2016;102:1793-6.

31. Valeti US, Nishimura RA, Holmes DR, Araoz PA, Glockner JF, Breen JF, et al. Comparison of surgical septal myectomy and alcohol septal ablation with cardiac magnetic resonance imaging in patients with hypertrophic obstructive cardiomyopathy. J Am Coll Cardiol. 2007;49:350-7.

32. El-Sabawi B, Nishimura RA, Barsness GW, Cha YM, Geske JB, Eleid MF. Temporal occurrence of arrhythmic complications after alcohol septal ablation. Circ Cardiovasc Interv. 2020;13:e008540.

33. McLeod CJ, Ommen SR, Ackerman MJ, Weivoda PL, Shen WK, Dearani JA, et al. Surgical septal myectomy decreases the risk for appropriate implantable cardioverter defibrillator discharge in obstructive hypertrophic cardiomyopathy. Eur Heart J. 2007;28:2583-8.

34. Sigwart U. Non-surgical myocardial reduction for hypertrophic obstructive cardiomyopathy. Lancet. 1995;346:211-4.

35. Durand E, Mousseaux E, Coste P, Pillière R, Dubourg O, Trinquart L, et al. Non-surgical septal myocardial reduction by coil embolization for hypertrophic obstructive cardiomyopathy: early and 6 months follow-up. Eur Heart J. 2008;29:348-55.

36. Liu H, Wu Q, Tan HW, Pang J. The efficacy and safety of coil embolization of septal branch in the treatment of patients with obstructive hypertrophic cardiomyopathy. Zhonghua Xin Xue Guan Bing Za Zhi. 2017;45:1044-8.

37. Asil S, Kaya B, Canpolat U, Yorgun H, Şahiner L, Çöteli C, et al. Septal reduction therapy using nonalcohol agent in hypertrophic obstructive cardiomyopathy: single center experience. Catheter Cardiovasc Interv. 2018;92:557-65.

38. Alyaydin E, Jánosi RA, Luedike P, Rassaf T, Papathanasiou M. Septal microsphere embolization in hypertrophic obstructive cardiomyopathy. Am J Cardiol. 2023;201:116-22.

39. Okutucu S, Aytemir K, Oto A. Glue septal ablation: a promising alternative to alcohol septal ablation. JRSM Cardiovasc Dis. 2016;5:2048004016636313.

40. Oto A, Aytemir K, Okutucu S, Kaya EB, Deniz A, Cil B, et al. Cyanoacrylate for septal ablation in hypertrophic cardiomyopathy. J Interv Cardiol. 2011;24:77-84.

41. Wang Z, Zhao R, Sievert H, Ta S, Li J, Bertog S, et al. First-in-man application of Liwen RF™ ablation system in the treatment of drug-resistant hypertrophic obstructive cardiomyopathy. Front Cardiovasc Med. 2022;9:1028763.

42. Zhou M, Ta S, Hahn RT, Hsi DH, Leon MB, Hu R, et al. Percutaneous intramyocardial septal radiofrequency ablation in patients with drug-refractory hypertrophic obstructive cardiomyopathy. JAMA Cardiol. 2022;7:529-38.

43. Wang H, Li J, Hsi DH, Li W, Ta S, Jiao Y, et al. Percutaneous intramyocardial septal radiofrequency ablation: a novel treatment for drug-refractory non-obstructive hypertrophic cardiomyopathy with severe septal hypertrophy. Heart. 2025:heartjnl-2024-325334. doi: 10.1136/heartjnl-2024-325334. Epub ahead of print.

44. Takayama H, Chung WK, Maurer MS, Ginns JN. Hypertrophic cardiomyopathy: new approaches and a time to reappraise older approaches. J Thorac Cardiovasc Surg. 2016;152:983-8.

45. Smedira NG, Lytle BW, Lever HM, Rajeswaran J, Krishnaswamy G, Kaple RK, et al. Current effectiveness and risks of isolated septal myectomy for hypertrophic obstructive cardiomyopathy. Ann Thorac Surg. 2008;85:127-33.

46. Maron BJ, Dearani JA, Smedira NG, Schaff HV, Wang S, Rastegar H, et al. Ventricular septal myectomy for obstructive hypertrophic cardiomyopathy (analysis spanning 60 years of practice): AJC Expert Panel. Am J Cardiol. 2022;180:124-39.

47. Pruna-Guillen R, Pereda D, Castellà M, Sandoval E, Affronti A, García-Álvarez A, et al. Outcomes of septal myectomy beyond 65 years, with and without concomitant procedures. J Clin Med. 2021;10:3499.

48. Mentias A, Smedira NG, Krishnaswamy A, Reed GW, Ospina S, Thamilarasan M, et al. Survival after septal reduction in patients >65 years old with obstructive hypertrophic cardiomyopathy. J Am Coll Cardiol. 2023;81:105-15.

49. Desai MY, Owens A, Geske JB, Wolski K, Saberi S, Wang A, et al. Dose-blinded myosin inhibition in patients with obstructive hypertrophic cardiomyopathy referred for septal reduction therapy: outcomes through 32 weeks. Circulation. 2023;147:850-63.

50. Cresci S, Bach RG, Owens AT, Lakdawala NK, Saberi S, Hegde SM. Response to mavacamten in patients with high baseline left ventricular filling pressures in the EXPLORER-HCM trial. Circ Cardiovasc Imaging. 2025;18:e017824.

51. Tian Z, Li X, Li L, Zhang Q, Wang J, Shi Y, et al. Effect of mavacamten on echocardiographic features in chinese patients with obstructive hypertrophic cardiomyopathy: results from the EXPLORER-CN study. Cardiol Ther. 2025;14:267-82.

52. Desai MY, Owens A, Saberi S, Wang A, Wolski K, Cremer PC, et al; VALOR-HCM investigators. Long-term effects of mavacamten on patients based on hypertrophic cardiomyopathy pathogenic genetic variant status: insights from VALOR-HCM trial. Circ Genom Precis Med. 2025;18:e005100.

53. Maron MS, Gimeno JR, Veselka J, Barriales-Villa R, Claggett BL, Coats CJ, et al; SEQUOIA-HCM investigators. Efficacy of Aficamten in patients with obstructive hypertrophic cardiomyopathy and mild symptoms: results from the SEQUIOA-HCM trial. Eur Heart J. 2025;ehaf364. doi: 10.1093/eurheartj/ehaf364. Epub ahead of print.

54. Maron MS, Masri A, Nassif ME, Barriales-Villa R, Abraham TP, Arad M, et al; SEQUOIA-HCM investigators. Impact of Aficamten on disease and symptom burden in obstructive hypertrophic cardiomyopathy: results from SEQUOIA-HCM. J Am Coll Cardiol 2024;84:1821-31.

55. Desai MY, Tower-Rader A, Szpakowski N, Mentias A, Popovic ZB, Smedira NG. Association of septal myectomy with quality of life in patients with left ventricular outflow tract obstruction from hypertrophic cardiomyopathy. JAMA Netw Open. 2022;5:e227293.

56. Tower-Rader A, Szpakowski N, Popovic ZB, Bittel B, Fava A, Ospina S, et al. Patient reported outcomes in obstructive hypertrophic cardiomyopathy undergoing myectomy: results from SPIRIT-HCM study. Prog Cardiovasc Dis. 2023;80:66-73.

57. Fang J, Wang R, Liu H, Su Y, Chen J, Han X, et al. Transapical septal myectomy in the beating heart via a minimally invasive approach: a feasibility study in swine. Interact Cardiovasc Thorac Surg. 2020;30:303-11.

58. Fang J, Liu Y, Zhu Y, Li R, Wang R, Wang DW, et al. First-in-human transapical beating-heart septal myectomy in patients with hypertrophic obstructive cardiomyopathy. J Am Coll Cardiol. 2023;82:575-86.

59. Zhao Y, Huang L, Li C, Tang D, Luo Y, Xiang C, et al. Improvement in coronary microvascular dysfunction evaluated by cardiac magnetic resonance in patients with hypertrophic obstructive cardiomyopathy after transapical beating-heart septal myectomy. Front Cardiovasc Med. 2023;10:1233004.

60. Zhao Y, Li C, Tang D, Luo Y, Xiang C, Huang L, et al. Early reverse remodeling of left heart morphology and function evaluated by cardiac magnetic resonance in hypertrophic obstructive cardiomyopathy after transapical beating-heart septal myectomy. J Cardiovasc Magn Reson. 2023;25:70.

61. Li J, Chen Y, Li R, Fang J, Quintana E, Wei X. Transapical beating heart septal myectomy learning curve and training of future surgeons: an observational study. Int J Surg. 2024;110:7729-37.

62. Fang J, Chen Y, Liu Y, Li R, Zhu Y, Zhou W, et al. Transapical beating-heart septal myectomy for obstructive hypertrophic cardiomyopathy: lessons learned after the learning curve period. Circ Cardiovasc Interv. 2025;18:e015044.