THE TEXAS HEART INSTITUTE® JOURNAL

History of Medicine

Closed Mitral Valvotomy: Celebrating 100 Years of Surgical History

Uberto Bortolotti, MD[1]; Igor Vendramin, MD[1]; Aldo Domenico Milano, MD, PhD[2]; Ugolino Livi, MD[1]

[1]Cardiothoracic Department, University Hospital, Udine, Italy
[2]Division of Cardiac Surgery, University Hospital, Bari, Italy

Abstract

The year 2023 marks the 100th anniversary of the first successful valvotomy for mitral valve stenosis by Elliott C. Cutler in 1923. Closed-chest mitral valve commissurotomy developed further before being replaced by an open procedure after the advent of the heart-lung machine. Currently, because of the almost complete disappearance of rheumatic disease in the Western World, mitral commissurotomies are infrequently performed in those countries, although the procedure—either closed or open—is still performed in developing countries and select patients. This review retraces the 100-year journey from a historic operation to the current era—a milestone in the treatment of patients with mitral stenosis.

Keywords: Mitral valve; mitral valve stenosis; mitral valve surgery

"The index finger is still the best instrument."
—Mark M. Ravitch, MD (1910-1989)

Introduction

From both the available literature and his drawings, there is enough evidence that Leonardo da Vinci (1452-1519) knew very well the anatomy and physiology of the heart—and particularly the mitral valve apparatus. Such detailed studies were subsequently instrumental for further expanding knowledge of the heart and valvular diseases. More than a century later, mitral valve stenosis (MVS) was first described by John Mayow (1640-1679), an English pathologist, who observed an extreme constriction of the valve. Just a few years later, Giovan Battista Morgagni (1682-1771) confirmed this observation, defining the constriction as an ossification of the mitral valve.[1] In the years that followed, both the typical clinical pictures and the auscultatory findings of MVS were recognized, allowing physicians to reach a correct diagnosis in many cases.[2,3]

Soon thereafter, surgeons relived MVS in the anatomical theater by using commissural opening, advancing the hypothesis that surgical treatment of a stenotic mitral valve could be performed.[4-6] This procedure was effectively performed for the first time only 20 years after those initial assumptions. Undoubtedly, the operation dramatically changed the outlook for patients with MVS, giving them a new "lease on life." This article presents a hundred-year-long journey from this historical undertaking.

Cutler's Milestone Operation

The first closed-chest mitral valvotomy for MVS was performed by Elliott C. Cutler and Samuel A. Levine on May 20, 1923, at Brigham Hospital in Boston, Massachusetts.[4] The patient was a 12-year-old girl who presented

Citation: Bortolotti U, Vendramin I, Milano AD, Livi U. Closed mitral valvotomy: celebrating 100 years of surgical history. *Tex Heart Inst J.* 2023;50(3):e228007. doi:10.14503/THIJ-22-8007
Corresponding author: Uberto Bortolotti, MD, Largo Traiano, 23, 35036 Montegrotto Terme, Italy (uberto48@gmail.com)

with exertional dyspnea and hematic sputum. The diagnosis was made on clinical grounds: "On auscultation the heart was found to be regular—126 to the minute. There was a moderate systolic murmur at the apex and a louder rumbling diastolic murmur, filling the entire diastole and ending with a presystolic accentuation and a somewhat snapping first heart sound."[4] Chest x-ray, electrocardiogram, and pulmonary function test results were also suggestive of MVS. Five days after the final diagnosis, the operation was performed. The approach was through a long median skin incision, followed by median sternotomy up to the second intercostal space. When the heart had been isolated, it was gently pulled upwards, and a valvotome was inserted into the left ventricular apex. Subsequently,

> the knife was pushed upwards, until it encountered what seemed to us must be the mitral orifice. It was then turned mesially, and a cut made in what we thought was the aortic leaflet, the resistance encountered being very considerable. The knife was quickly turned and a cut made in the opposite side of the opening. The knife was then withdrawn and the mattress sutures already in place were tied over the point at which the knife had been inserted.

In reading the detailed description of the procedure, all the surgeon's uncertainty and anxiety can be appreciated. Because the heart proved to be particularly sensitive to manipulation, a desired repeat procedure was avoided.

The postoperative course was complicated by a right lung pneumonia, which completely resolved. Cardiac murmurs were still present but with reduced intensity, probably partly masked by pericardial effusion, which was left untreated. For this reason, the real efficacy of the operation and the clinical benefits could not be clearly assessed at that stage. The conclusions by the authors were extremely reasonable and fair:

> The experience with this case, however, is of importance in that it does show that surgical intervention in cases of mitral stenosis bears no special risk, and should give us further courage and support in our desire to attempt to alleviate a chronic condition, for which there is now not only no treatment, but one which carries a terrible prognosis.

The patient was discharged home in an improved condition, most likely with an unspecified degree of residual mitral regurgitation. She died from pneumonia 4.5 years later.[5]

Abbreviations and Acronyms

MBS	mitral valve stenosis
PBV	percutaneous balloon valvuloplasty

Cutler's first mitral valvotomy was performed through the left ventricle using a valvotome, which was described as "an instrument somewhat similar to a tenotome or a slightly curved tonsil knife," which had been used experimentally for the same procedure (Fig. 1).[4,5] Because Cutler referred to the instrument as a "knife" used to cut the mitral leaflets, it is likely that during such a blind operation, dilatation of the mitral valve was not directed to cut the commissures precisely for relief of the stenosis but involved the leaflets, as well, thus creating iatrogenic regurgitation. Indeed, other patients underwent the procedure using the same technique with disastrous results, dying in the first postoperative days because of massive mitral insufficiency.[5]

Evolution of Surgical Techniques for Mitral Stenosis

During the initial attempts to repair MVS in animals, Allen and Graham proposed the use of a cardioscope, a tubular instrument that could allow direct intracardiac

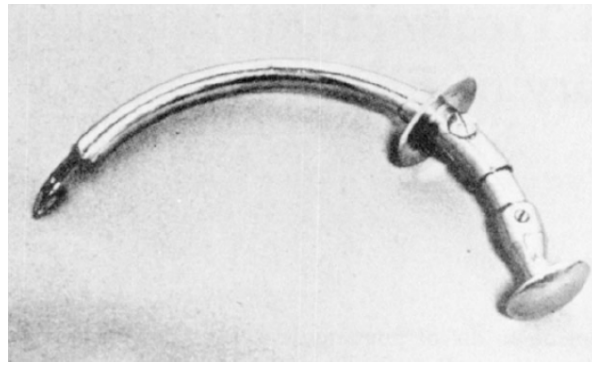

Fig. 1 Image of the valvotome Cutler and Levine used in 1923 for the first closed mitral stenosis procedure. The instrument, similar to a knife, was introduced through the left ventricular apex to blindly cut the valve commissures.

vision; the procedure was well tolerated in dogs when the instrument was introduced through the left atrium, but it did not go beyond the experimental phase.[6] On May 6, 1925, Henry S. Souttar performed the first digital mitral valve dilatation in a patient with concomitant regurgitation; because the mitral stenosis was moderate, with only a little leaflet thickening, the procedure was limited "to such dilatation as could be carried out by the finger."[7] In any case, Souttar demonstrated that by inserting a finger into the left atrium through the left atrial appendage, the mitral valve could be explored and dilated without the use of any cutting instrument and without disturbing the heart.[8]

As can be seen from both Cutler's and Souttar's papers, the term commissurotomy was never mentioned. Indeed, this term would be coined in 1948 by Charles P. Bailey, who performed what he considered the first modern corrective operation for mitral stenosis.[9,10] After some preliminary unsuccessful attempts, Bailey presented "the concept of separating the fused valve leaflets anatomically along the lines of the obliterated commissures," thus relieving stenosis without creating regurgitation.[10] For his first operation, he used a hooked knife attached to a finger to divide the fused commissures. Dwight E. Harken performed a similar operation in a 27-year-old man with mitral stenosis just 6 days after the 1 performed by Bailey; this timeline most likely contributed to the controversy over which surgeon was to be credited as the first to undertake that historic operation.[11] Controversy also exists on the better surgical approach for the treatment of MVS. Introducing an instrument through the left ventricular apex was in some cases difficult and could stimulate important arrhythmias, even causing cardiac arrest. The left atrium, accessed through a left thoracotomy, appeared a more favorable approach than the left ventricle because the atrium would be easier to manipulate. It could cause mobilization of thrombi, however, and tearing of a thin and fragile structure following atrial distention, with severe bleeding.[10] In the same way, presence of a left atrial myxoma, misdiagnosed for mitral stenosis, could cause tumor embolization if a closed mitral commissurotomy had been attempted.[12]

Contrary to the general attitude, Bailey proposed a right lateral approach to mitral commissurotomy.[10] From the right side, the left atrium could be entered through the interatrial groove using a purse-string suture on the dissection line. The main advantage of the right-sided approach was considered to be the possibility of more easily reaching both mitral valve commissures. Indeed, as Bailey stated, in the majority of patients who had previously undergone an operation for MVS from the left, only the anterolateral commissure was separated.[10] Because the anatomical orientation of the mitral valve through a right thoracotomy is different from that of a left-sided approach, however, one should be adequately prepared to face this new situation.[10] From the right approach, it was more difficult to remove thrombi from the left atrium digitally; for this reason, an "aspirating tip" was introduced though the same incision to withdraw thrombotic material. In the first 200 patients undergoing the procedure from the right side, both mitral commissures were separated in 195 of them (97.5%), with an overall hospital mortality rate of 8%.[10] Interestingly, others in the same time period used either the transatrial or transventricular approach to introduce an instrument that could produce a hole in the mitral valve, partially relieving stenosis without creating significant insufficiency.[13]

Instruments for Mitral Commissurotomy

Regardless of surgical approach, the instruments used to relieve MVS have evolved. The knife Cutler used was ineffective and replaced by digital opening, referred to as "finger fracture" of the mitral commissures, performed for the first time in 1925.[7] Subsequently, various instruments have been used. Harken et al[14] in 1948 reported the use of a "cardiovalvulotome" similar to the 1 Cutler employed, introduced through the left atrium or 1 of the left pulmonary veins; the cutting edge of the instrument was not easy to manipulate, so after enlargement of the mitral orifice, a certain degree of "selective insufficiency" could be accepted. Bailey and Dryden P. Morse performed mitral commissurotomy using a guillotine knife,[10] a device similar to that used by H.T. Nichols and W.L. Jamison in 1955 to treat subvalvular mitral stenosis.[13] In many patients with MVS, particularly in those with long-standing disease, fusion of the subvalvular apparatus was frequently present that could not be treated using digital pressure only. In these patients, a modified guillotine knife with a blunt, golf club–angled lower end was used effectively.[14] In Italy, Achille M. Dogliotti used a metallic ring inserted through the left atrium on the tip of the forefinger and provided with a scimitar blade that was directed toward the commissures. He used this technique on more than 2,500 patients with MVS.[15]

By the early 1950s, Charles Dubost in Paris had treated a series of 1,000 patients with MVS by using a dilator inserted through the left atrium.[16] Based on this experience, a similar dilator was devised in 1954 by Oswald H. Tubbs that consisted of 2 flat handles that controlled the opening of the central blade and 2 lateral bars; when the handle was pushed, the dilator expanded up to 45 mm in width (Fig. 2A and 2B).[17] This dilator was introduced through the left ventricular apex, guided into the mitral orifice by a finger inserted in the left atrial appendage, and progressively opened (Fig. 2C). There has been some controversy over the proper use of mechanical dilators, particularly on their correct orientation. For some surgeons, the orientation of the instrument was not relevant[17]; others recommended positioning the blades against the commissures,[18] while still others preferred to open the dilator blades perpendicular to the midpoint of the leaflets.[19] In any case, treatment of MVS with the Tubbs dilator provided results superior to those with digital valvotomy because the posteromedial commissure was difficult to reach and open adequately using either a bare finger or a knife.[17] Contrary to the use of fingers, knives, or rings, with dilators, the commissures are not cut but torn and split; therefore, the term commissurotomy became inappropriate for this procedure (a still better term is commissural avulsion). The Tubbs dilator gained great popularity and was employed in many cases,[17-20] even with some modifications of the original instrument.[21]

A curved valvotome was used in 1948 by Russel C. Brock in London to treat pulmonary valve stenosis.[22] The same instrument was subsequently employed in patients with MVS,[23] at times used with scissors.[24] F.R. Edwards used a "mechanical splitter," introduced through the left ventricle or the left atrium and oriented toward the commissures.[25] Others have devised a metal strip with a curved end, molded on the dorsum of the index finger; when the finger is flexed, the instrument presses each commissure, separating the mitral leaflets (Fig. 3).[26]

Results of Closed and Open Mitral Commissurotomy

After the advent of the heart-lung machine, relief of MVS by closed techniques became partly outdated. Starting in 1960,[27] open commissurotomy rapidly became the procedure of choice for the conservative treatment of MVS.[28-30] The evident advantages of an open

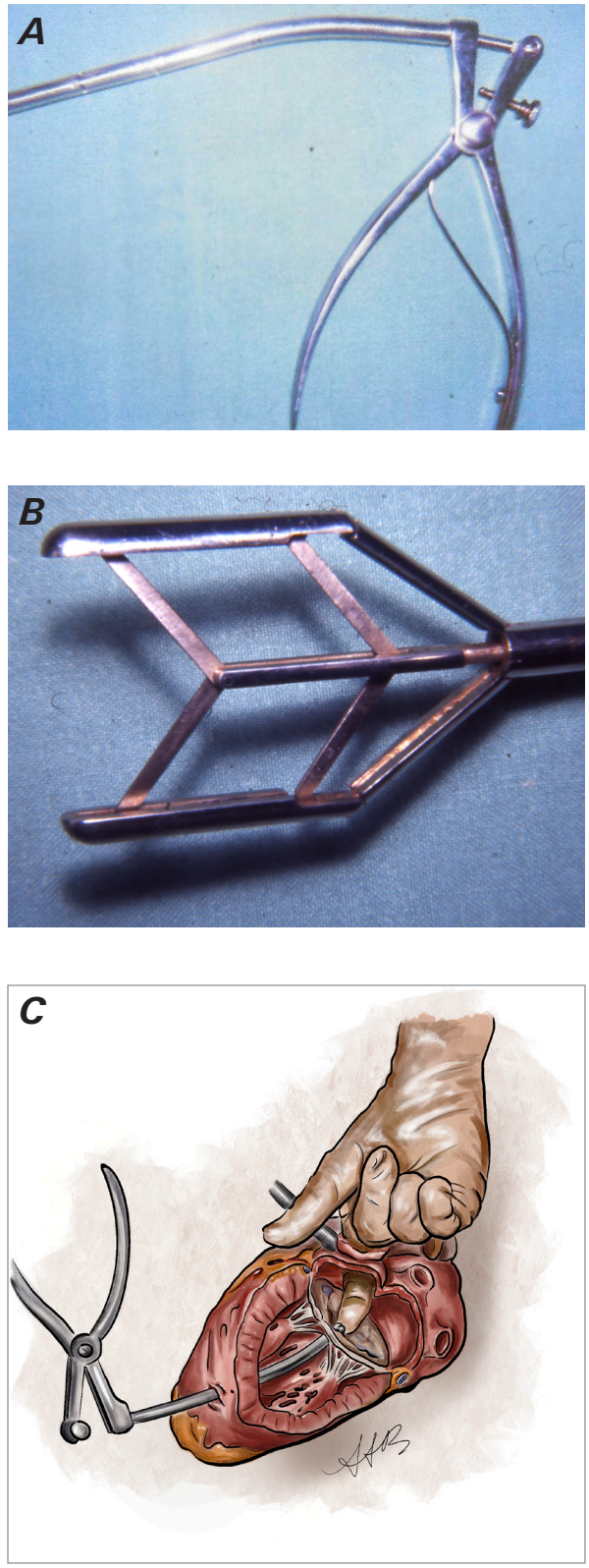

Fig. 2 Image of a Tubbs mechanic dilator **A**) and its open tip **B**). **C**) Drawing showing insertion of the dilator in the left ventricle, guided into the mitral valve by the forefinger, introduced through the left atrial appendage.

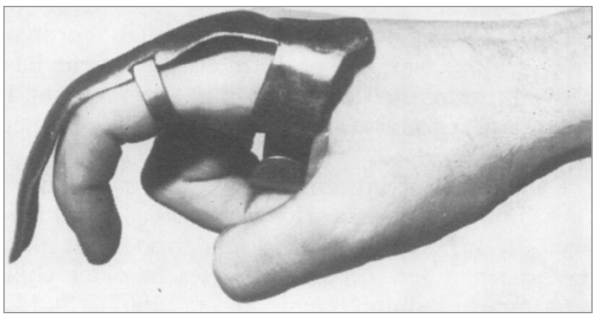

Fig. 3 Image of the mitral commissure-splitting instrument used by Earle B. Kay et al in 1960. The device was applied to the superior aspect of the index finger, which, once extended, exerted adequate pressure on the mitral leaflets to open the commissures.

over a closed technique were represented by the possibility of directly visualizing and inspecting the mitral valve to assess its suitability for commissurotomy. Furthermore, a better anatomical result could be obtained by cutting the commissures following the precise line of fusion (Fig. 4A) and by extending the repair to the subvalvular structures. The papillary muscles and fused chordae tendineae could be split (Fig. 4B), re-creating the interchordal spaces and increasing the mobility and area of the whole mitral valve apparatus. Finally, immediate assessment of the anatomical and functional result could be made. Visual inspection of the mitral valve has led to performing fewer commissurotomies than would have been done using a closed approach[31]; indeed, open repair yielded superior results in select patients with pure, severe, noncalcific MVS.[32] In addition, open mitral commissurotomy could be performed on valves with some degree of calcification, a contraindication to a closed procedure, thus avoiding prosthetic valve replacement. For these reasons, closed mitral commissurotomy was gradually abandoned in most centers.[33]

The results of closed vs open mitral commissurotomy have been somewhat controversial. John et al[34] in 1983 published the largest series of patients undergoing closed mitral commissurotomy for MVS. During a 25-year interval, this procedure was performed in 3,724 consecutive patients, with an overall mortality rate under 4% and 84% survival at 24 years. In 1993, Scalia et al,[35] analyzing 280 patients over 20 years, concluded that open commissurotomy offered no better results than closed valvotomy in properly selected candidates. Detter

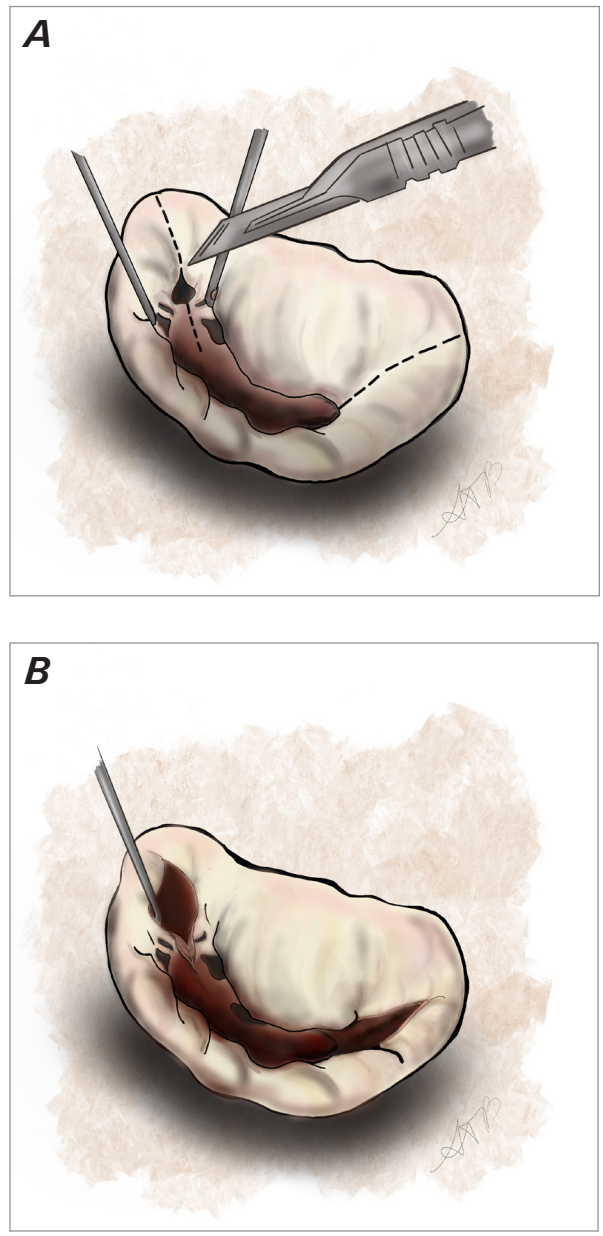

Fig. 4 Drawing showing the basic steps of open mitral commissurotomy. **A**) A No. 11 scalpel blade separates the fused commissures up to 1 to 2 mm from the mitral annulus; the commissures are cut following the dotted line. **B**) When needed, splitting the head of a papillary muscle or the fused chordae can be added.

et al[36] reported in 1999 their experience with closed and open mitral commissurotomy in 143 patients, showing excellent results up to 35 years and no significant differences between the 2 techniques. In 2015, Sherawat et al[37] reported a single-center experience with closed mitral valvotomy showing a 0.5% mortality rate and 75% freedom from reoperation at 20 years.

Percutaneous Balloon Valvuloplasty

Percutaneous balloon valvuloplasty (PBV) was introduced by Inoue et al[38] in 1983; this less-invasive procedure received great support from the development of transesophageal echocardiography, which could more precisely define mitral valve anatomy, guide the balloon through the orifice, and allow immediate assessment of the results. In many centers, PBV has become the preferred treatment for MVS, particularly in carefully selected patients with tight MVS and commissural fusion with absent or minimal calcification. Percutaneous balloon valvuloplasty has been demonstrated to be safe and effective, providing clinical and hemodynamic improvement in patients with MVS. Immediate success is achieved when doubling of the mitral valve area occurs, obtaining an average of more than 2 cm^2 of the final mitral valve area.[39] Long-term results currently available indicate 98% and 87% survival at 9 and 12 years after PBV, respectively. The best results are obtained in young patients with sinus rhythm, no pulmonary hypertension, and no evidence of calcification of the mitral valve. In this subset, PBV appears to be superior to surgical commissurotomy.[39]

The Current Role of Mitral Commissurotomy

The considerable reduction in the incidence of rheumatic disease and consequent valvular involvement has effectively eliminated closed mitral commissurotomy in the Western World and markedly reduced the open procedure, which not many years ago was still considered a "good operation."[31] For the same reason, closed mitral commissurotomy, like many old and seemingly useless procedures, regrettably is not taught anymore to young surgeons. In developing countries with limited financial resources and where rheumatic heart disease is still prevalent, however, closed mitral commissurotomy is often performed by skilled surgeons and has a definite role.[33] Ravikrishan et al,[40] comparing balloon with closed mitral valvuloplasty, have shown better results and particularly lower costs with such a surgical technique, even in recent years. Moreover, a reusable percutaneous mechanical dilator, using a transseptal approach and mimicking the Tubbs principle, was recently introduced as an alternative to the Inoue balloon, with considerable reduction in costs.[41]

Conclusion

Mitral valvotomy represents a milestone in the treatment of patients with MVS. This landmark operation has been subsequently replaced by increasingly more accurate closed and open procedures. Despite the excellent results reported with mitral commissurotomy, however, its role has been progressively limited by the reduction of rheumatic valve disease in the Western World and by the introduction of less-invasive, catheter-based procedures (Table I).[1,4,7,9,17,27,38] It took almost 50 years to introduce mitral valvotomy into clinical practice following the first suggestion that MVS could be relieved surgically, but as many developing countries have shown, mitral commissurotomy together with PBV remains a valid option for select patients. At present, because of the limited financial resources of countries where rheumatism is still endemic, both closed and open commissurotomies are still performed; indeed, they are considered valid and cost-effective options, especially in young patients with rheumatic MVS.[31]

TABLE I. Important Steps in the Diagnosis and Treatment of Mitral Valve Stenosis

Reference	Event
Rolleston (1941)[1]	In 1668, John Mayow described the pathoanatomical findings of MVS.
Rolleston (1941)[1]	In 1761, Giovan Battista Morgagni described MVS as "ossification of the mitral valve" on a pathological specimen.
Cutler and Levine (1923)[4]	Elliott C. Cutler performed the first closed mitral valvotomy on May 20, 1923, at Brigham Hospital in Boston, MA, on a 12-year-old girl.
Souttar (1925)[7]	The first digital dilatation of a stenotic mitral valve was reported by Henry S. Souttar in 1925.
Bailey (1949)[9]	Charles P. Bailey is credited with performing the first mitral "commissurotomy" in 1948. The procedure was published in 1949.
Logan and Turner (1959)[17]	Andrew Logan used the Tubbs mechanical dilator to treat MVS for the first time in 1954. He reported his results in 1959.
Kay et al (1960)[27]	Kay reported a series of 22 patients with pure mitral stenosis treated by open mitral commissurotomy.
Inoue et al (1984)[38]	Kanji Inoue introduced the clinical use of transvenous mitral commissurotomy by using a balloon catheter in 1983. He reported his experience in 1984.

MVS, mitral valve stenosis.

Acknowledgments

The authors wish to thank Barbara Zaramella and Anna Teresa Bortolotti for their technical support and art work and Julie Anne Miles, EMT, for reviewing the manuscript.

Published: 15 May 2023

Author Contributions: U.B. was involved in writing the paper, I.V. in the literature search, A.D.M. in the data analysis, and U.L. in review and approval of the manuscript.

Conflict of Interest Disclosure: The authors have nothing to disclose.

Funding/Support: None.

References

1. Rolleston H. The history of mitral stenosis. *Br Heart J.* 1941;3(1):1-12. doi:10.1136/hrt.3.1.1
2. Bajaj SS, Fann JI. History of surgery for mitral stenosis: John Mayow to Charles Bailey. *Ann Thorac Surg.* 2022;113(6):2097-2101. doi:10.1016/j.athoracsur.2021.12.046
3. Brunton L. Preliminary note on the possibility of treating mitral stenosis by surgical methods. *Lancet.* 1902;159(4093):352. doi:10.1016/S0140-6736(01)81502-6
4. Cutler EC, Levine SA. Cardiotomy and valvulotomy for mitral stenosis. Experimental observations and clinical notes concerning an operated case with recovery. *Boston Med Surg J.* 1923;188(26):1023-1027. doi:10.1056/NEJM192306281882601
5. Cohn LH. The first successful surgical treatment of mitral stenosis: the 70th anniversary of Elliott Cutler's commissurotomy. *Ann Thorac Surg.* 1993;56(5):1187-1190. doi:10.1016/0003-4975(95)90049-7
6. Allen DS, Graham EA. Intracardiac surgery—a new method. *JAMA.* 1922;79(13):1028-1030. doi:10.1001/jama.1922.02640130020005
7. Souttar HS. The surgical treatment of mitral stenosis. *Br Med J.* 1925;2(3379):603-606. doi:10.1136/bmj.2.3379.603
8. Weisse AB. The surgical treatment of mitral stenosis: the first heart operation. *Am J Cardiol.* 2009;103(1):143-147. doi:10.1016/j.amjcard.2008.08.040
9. Bailey CP. Surgical treatment of mitral stenosis. *Dis Chest.* 1949;15(4):377-397. doi:10.1378/chest.15.4.377
10. Bailey CP, Morse DP. Mitral commissurotomy performed from the right side. *J Thorac Surg.* 1957;33(4): 427-486.
11. Tesler UF. Mitral valve repair. Historical evolution and what lies ahead. *Texas Heart Inst J.* 2012;39(6):862-865.
12. Harrison JW, McCormack LJ, Ernstene AC. Myxoma of the left atrium simulating mitral stenosis. *Circulation.* 1954;10(5):766-771. doi:10.1161/01.cir.10.5.766
13. Nichols HT, Jamison WL. Subvalvular mitral stenosis; its recognition and treatment. *J Thorac Surg.* 1955;29(6):611-617.
14. Harken DE, Ellis LB, Ware PF, Norman LR. The surgical treatment of mitral stenosis; valvuloplasty. *N Engl J Med.* 1948;239(22):801-809. doi:10.1056/NEJM194811252392201
15. Dogliotti AM, Actis-Dato A, Gentili R. Digital and instrumental commissurotomy in mitral stenosis; a study of 2,000 cases. *Surgery.* 1958;44(4):706-717.
16. Dubost C, Blondeau P, Piwnica A. Instrumental dilatation using the transatrial approach in the treatment of mitral stenosis. A survey of 1000 cases. *J Thorac Cardiovasc Surg.* 1962;44(3):392-407. doi:10.1016/S0022-5223(19)32961-7
17. Logan A, Turner R. Surgical treatment of mitral stenosis with particular reference to the transventricular approach with a mechanical dilator. *Lancet.* 1959;2(7108):874-880. doi:10.1016/s0140-6736(59)90805-0
18. Cooley DA, Stoneburner JM. Transventricular mitral valvulotomy. *Surgery.* 1959;46(2):414-420.
19. Austen WG, Wooler GH. Surgical treatment of mitral stenosis by the transventricular approach with a mechanical dilator. *N Engl J Med.* 1960;263;661-665. doi:10.1056/NEJM19601006263140
20. Morrow AG, Braunwald NS. Transventricular mitral commissurotomy. Surgical technique and a hemodynamic evaluation of the method. *J Thorac Cardiovasc Surg.* 1961;41(2):225-235.
21. Banerjee A, Subbarao KSVK, Nachiappan M, Mandana KM. A modified Tubbs ventriculotomy-cum-mitral valve dilator. *Indian J Thorac Cardiovasc Surg.* 1989;6(1):84-85. doi:10.1007/BF02664034
22. Brock RC. Pulmonary valvulotomy for the relief of congenital pulmonary valve stenosis. report of tree cases. *Br Med J.* 1948;1(4562):1121-1126. doi:10.1136/bmj.1.4562.1121
23. Baker C, Brock RC, Campbell M. Valvulotomy for mitral stenosis; report of six successful cases. *Br Med J.* 1950;1(4665):1283-1293. doi:10.1136/bmj.1.4665.1283
24. Nauta J, Harman H. The use of instruments in commissurotomy for mitral stenosis. *Thorax.* 1962;17(1):85-90. doi:10.1136/thx.17.1.85
25. Edwards FR. Instrumental transatrial mitral valvotomy. *Thorax.* 1962;17(3):271-273. doi:10.1136/thx.17.3.271
26. Sancho-Fornos S, Arnau BN. A new instrument for closed mitral commissurotomy: 10 years' experience. *Thorax.* 1971;26(4):486-487. doi:10.1136/thx.26.4.486
27. Kay EB, Nogueira C, Zimmermann HA. Surgical treatment of mitral stenosis by open technique. *JAMA.* 1960;173:1644-1649. doi:10.1001/jama.1960.03020330012003
28. Finnegan JO, Gray DC, MacVaugh H III, Joyner CR, Johnson J. The open approach to mitral commissurotomy. *J Thorac Cardiovasc Surg.* 1974:67(1):75-82.
29. Antunes MJ, Vieira H, Ferrão de Olivera J. Open mitral commissurotomy: the 'golden standard'. *J Heart Valve Dis.* 2000;9(4):472-477.
30. Kay PH, Belcher P, Dawkins K, Lennox SC. Open mitral valvotomy: fourteen years' experience. *Br Heart J.* 1983;50(1):4-7. doi:10.1136/hrt.50.1.4
31. Roberts WC. Mitral commissurotomy—still a good operation. *Am J Cardiol.* 1983;52(3):A9-A10. doi:10.1016/0002-9149(83)90110-8
32. Farhat MB, Moussadia H, Gandjbakhch I, et al. Closed versus open mitral commissurotomy in pure noncalcific mitral stenosis: hemodynamic studies before and after operation. *J Thorac Cardiovasc Surg.* 1990;99(4):639-644.
33. Antunes MJ. Closed mitral commissurotomy—a cheap, reproducible and successful way to treat mitral stenosis. *J Thorac Dis.* 2020;12(3):146-149. doi:10.21037/jtd.2019.12.118
34. John S, Bashi VV, Jairaj P, et al. Closed mitral valvotomy: early results and long-term follow-up of 3724 consecutive

patients. *Circulation.* 1983;68(5):891-896. doi:10.1161/01.cir.68.5.891
35. Scalia D, Rizzoli G, Campanile F, et al. Long-term results of mitral commissurotomy. *J Thorac Cardiovasc Surg.* 1993;105(4):633-642.
36. Detter C, Fischlein T, Feldmeier C, Nollert G, Reichenspurner H, Reichart B. Mitral commissurotomy, a technique outdated? Long-term follow-up over a period of 35 years. *Ann Thorac Surg.* 1999;68(6):2112-2118. doi:10.1016/s0003-4975(99)00838-3
37. Sherawat RC, Dixit S, Yadav RK, Sharma A. The place of closed mitral valvotomy (CMV) procedure in the modern era: 20 years single center experience. *J Cardiothorac Surg.* 2015;10(suppl 1):A319. doi:10.1186/1749-8090-10-S1-A319
38. Inoue K, Owaki T, Nakamura T, Kitamura F, Miyamoto N. Clinical application of transvenous mitral commissurotomy by a new transvenous catheter. *J Thorac Cardiovasc Surg.* 1984;87(3):394-402.
39. Palacios IF. Percutaneous mitral balloon valvuloplasty—state of the art. *Mini-invasive Surg.* 2020;4:73. doi:10.20517/2574-1225.2020.72
40. Ravikrishnan J, Arun N, Varkey AM. A prospective comparative study between closed mitral valvotomy and balloon valvoplasty as treatment for rheumatic non calcific mitral stenosis. *J Evol Med Dent Sci.* 2015;65(4):11298-11307. doi:10.14260/jemds/2015/1630
41. Cribier A, Rath PC, Letac B. Percutaneous mitral valvotomy with a metal dilator. *Lancet.* 1997;349(9066):1667. doi:10.1016/s0140-6736(97)24023-7