# SURGICAL CLOSED MITRAL COMISSUROTOMY FOR MITRAL STENOSIS

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***In the present study, 401 patients who had undergone successful closed mitral comissurotomy (CMC) were evaluated to determine the relationship between the time elapsed from surgery and clinical and functional status at presentation, and also the effect of calcification on restenosis. Functional capacity was noted both prior to CMC and at the presentation. Mitral valve area (MVA) was measured at the time of presentation. Patients were divided into 6 groups according to the time period between CMC and presentation [Group I (n=76) 2-5 years; Group II (n=113) 5-10 years; Group III (n=122) 10-15 years; Group IV (n=61) 15-20 years; Group V (n=21) 20-30 years and Group VI (n=8) over 30 years.] MVA's were 1.5±0.6, 1.35±0.39, 1.48±0.71, 1.32±0.44, 1.21±0.38, 1±0.22 $cm^2$ in groups I-VI, respectively. The percentage of patients who were in NewYork Heart Association (NYHA) Class I or II decreased progressively from Group I to IV, the percentage of patients with MVA ≥ 1.5 $cm^2$ were 59%, 44%, 39%, 38%, 33%, 37% in groups I-VI respectively. Severe restenosis (MVA ≤ 1.1 $cm^2$ ) occurred in 15%, 36%, 36%, 38%, 43%, 50% of cases in groups I-VI respectively. Clinical status and echocardiographic findings were not correlated well, and clinical success was significantly higher than echocardiographic success in groups I, II and III. Restenosis was also more frequent compared to functional derangement. Meanwhile the occurrence of severe restenosis and poor functional capacity was similar. CMC provides an effective and prolonged clinical relief until MVA becomes ≤ 1.1 $cm^2$ . Restenosis was seen more frequently and earlier in calcified mitral valves compared to noncalcified ones. These data suggest that CMC is a useful and cost effective procedure which should be preferred in selected cases in countries where the prevalence of rheumatic mitral stenosis is still high.***

***Key words: Mitral stenosis, closed mitral comissurotomy, mitral valve restenosis***

Rheumatic valvular disease is rare in Western countries, though it's still of particular importance in certain regions of the world[1,2], including Turkey. Among various forms of rheumatic heart disease, mitral stenosis is observed most frequently. Therefore, patients referred for surgical treatment of

rheumatic mitral stenosis should be cautiously evaluated and offered the most effective, and meanwhile the least costly procedure in terms of surgical therapy.

Closed mitral comissurotomy (CMC) performed since 1962 in our center is a simple and inexpensive technique compared to open comissurotomy and percutaneous balloon mitral valvotomy (PBMV), but has been replaced by the latter two since 1980's. During the clinical and echocardiographic follow-up of patients who had undergone successful CMC in our outpatient clinic, we have observed that these patients were still in good functional status, and had an acceptable mitral valve area (MVA) despite many years have passed over the procedure. We examined the relation between time interval from CMC to presentation and the functional status with echocardiographic mitral valve area (MVA), and also the effect of mitral valve calcification prior to CMC on the occurence of restenosis.

## MATERIALS and METHODS

Between 1962 and 1994, 7519 CMC operations have been undertaken in Siyami Ersek Cardiovascular and Thoracic Surgery Center. Patients who had undergone CMC at least two years previously, and who applied to the outpatient echocardiography department of our center between January 1993- January 1994 were included in this study. The success of CMC was assessed retrospectively according to the patient's file and the surgeon's notes taken during the operation. The criteria for successful operation were: 1. effective results such as cases in whom 1.5 or 2 fingers of the surgeon could reach the mitral valve orifice, and 2. no major complication during perioperative and postoperative in-hospital period, such as emergent cardiac reoperation, cardiac perforation and tamponade, acute mitral regurgitation, stroke, systemic embolic events, lung edema, cardio-pulmonary resuscitation, intubation, cardiac shock, acute myocardial infarction and pulmonary embolism.

Patients who had to undergo CMC twice, who had severe lesions of the other valves, with coronary arterial diseases, with left ventricle systolic dysfunction or with post-CMC rheumatic reactivation were not included in this study.

Cases were investigated in two periods:

1. Presentation period
2. CMC period (retrospectively)

**Presentation period:**

Routine check-up examinations were performed when the patient applied for follow-up at the outpatient echocardiography department. These included patient's history and functional capacity, physical examination, electrocardiography, chest-x-ray and echocardiography. All data were evaluated by the same clinician. Patient's functional class was noted according to the New York Heart Association (NYHA)[3] criteria.

Standart echocardiographic images were obtained at the parasternal long and short axis, apical two and four chamber planes. MVA was calculated from continuous mitral flow velocity profile, averaging 5 beats in patients with sinus rhythm, and >10 beats in those with atrial fibrillation[4,5]. The mean gradient (MVG) was derived by integration of instantaneous pressure gradients throughout diastole (using either the measurement package on the instrument or an off-line system) averaged from three to five consecutive beats in sinus rhythm and five to 10 consecutive beats in atrial fibrillation[5]. The Wilkins echocardiographic score (from 0 to 4) assigned the leaflet mobility, calcification, thickening and subvalvular thickening in 401 patients. Some of the individual features provided a total echocardiographic score[6,7], mitral regurgitation was graded on a 1 (+) -to-4(+) scale by colour Doppler echocardiography according to the jet extension in the left atrium, divided in 4 segments from the atrioventricular plane to the posterior wall[8]. Pulmonary arterial pressure was calculated from tricuspid regurgitation. By imaging two parasternal and apical cavities the size of the left atrium was determined. Transesophageal evaluation was not performed routinely. Diameters of the left ventricles and the thickness of the walls vere measured in M mode echocardiography.

Ventricular systolic functions were evaluated quantitatively.

**CMC period (retrospectively):**

Patients data were obtained from their files and the notes of the surgeon taken during the operation. Preoperative clinical status was classified according to NYHA and results were reported. Calcifications at the mitral valves detected before the operation flouroscopically or during the operation by the surgeon were also recorded. Since echocardiographic examination was performed in only Group I patients, these parameters were excluded.

**Classification:**

Cases were divided into six groups according to the time interval period between CMC and the presentation (Table 1).

**Criteria for success:**

Patients who were in NYHA functional classes I or II were accepted as clinically successful cases. The cases in postoperative classes III or IV were regarded as clinically unsuccessful. As for the echocardiographic parameters patients with MVA's of 1.5 $cm^2$, or more were accepted as succesfull long term results. Cases with MVA's below 1.5 $cm^2$ were defined as having restenosis, and the ones with 1.1 $cm^2$ or less as being severely restenosed.

**Statistics:**

Data were expressed as means and standart deviations. Their comparison were performed using te t test as applied to paired values, with the chi-square test used when appropriate. A p value less than 0.05 ($p<0.05$) was considered statistically significant.

## RESULTS

The age and sex of the patients according to the groups during the presentation period are shown in Table 2. In all of the groups the

**Table 1.** Classification according to the time interval between CMC (Closed mitral comissurotomy) and presentation.

| Group | | n |
|---|---|---|
| Group I* | 2-5 year | 76 |
| Group II | 5-10 year | 113 |
| Group III | 10-15 year | 122 |
| Group IV | 15-20 year | 61 |
| Group V | 20-30 year | 21 |
| Group VI | > 30 year | 8 |

* Group I patients were examined 2-5 years after CMC where as Group VI patients were seen 30 years after.

**Table 2.** Age and sex distribution at presentation.

| Group | n | Age (year) mean±SD (range) | Female/male |
|---|---|---|---|
| Group I | 76 | 39.3±12.4 (12-65) | 61 (80%) / 15 |
| Group II | 113 | 39.7±8.1 (27-58) | 90 (79%) / 23 |
| Group III | 122 | 42.4±10 (16-68) | 97 (79.5%) / 25 |
| Group IV | 61 | 48.5±8.9 (31-67) | 50 (82%) / 11 |
| Group V | 21 | 48.9±7.7 (34-64) | 15 (71.4%) / 6 |
| Group VI | 8 | 57±9 (43-66) | 6 (75%) / 2 |

majority of the patients were females (71-80%).

Figure 1 reveals the NYHA functional classes and comparison of the patients during the presentation and pre CMC periods.

MVA's and MVG's are shown in Table 3. MVA in Group I are significantly larger than in Groups V or VI, and similarly MVG's are lesser ($p<0.05$).

In Table 4, the three groups of mitral valve areas which are 1.5 $cm^2$ and more 1.5 $cm^2$ - 1.1 $cm^2$ and 1.1 $cm^2$ or less are compared according to their percentages. It has been found that while in Group I, 59% of valve areas were above 1.5 $cm^2$, no valve area was measured above 1.5 $cm^2$ in Group IV. The percentage of cases which were echocardiographically and clinically successful and their comparisons are given in Figure 2. It can readily be seen that, clinical success is significantly higher than the echocardiographic success in groups I, II and III ($p<0.05$). The percentage of echocardiographically restenosed cases was significantly higher than the percentage of clinically unsuccessful cases in the same groups (Table 5). No statistically significant difference could be

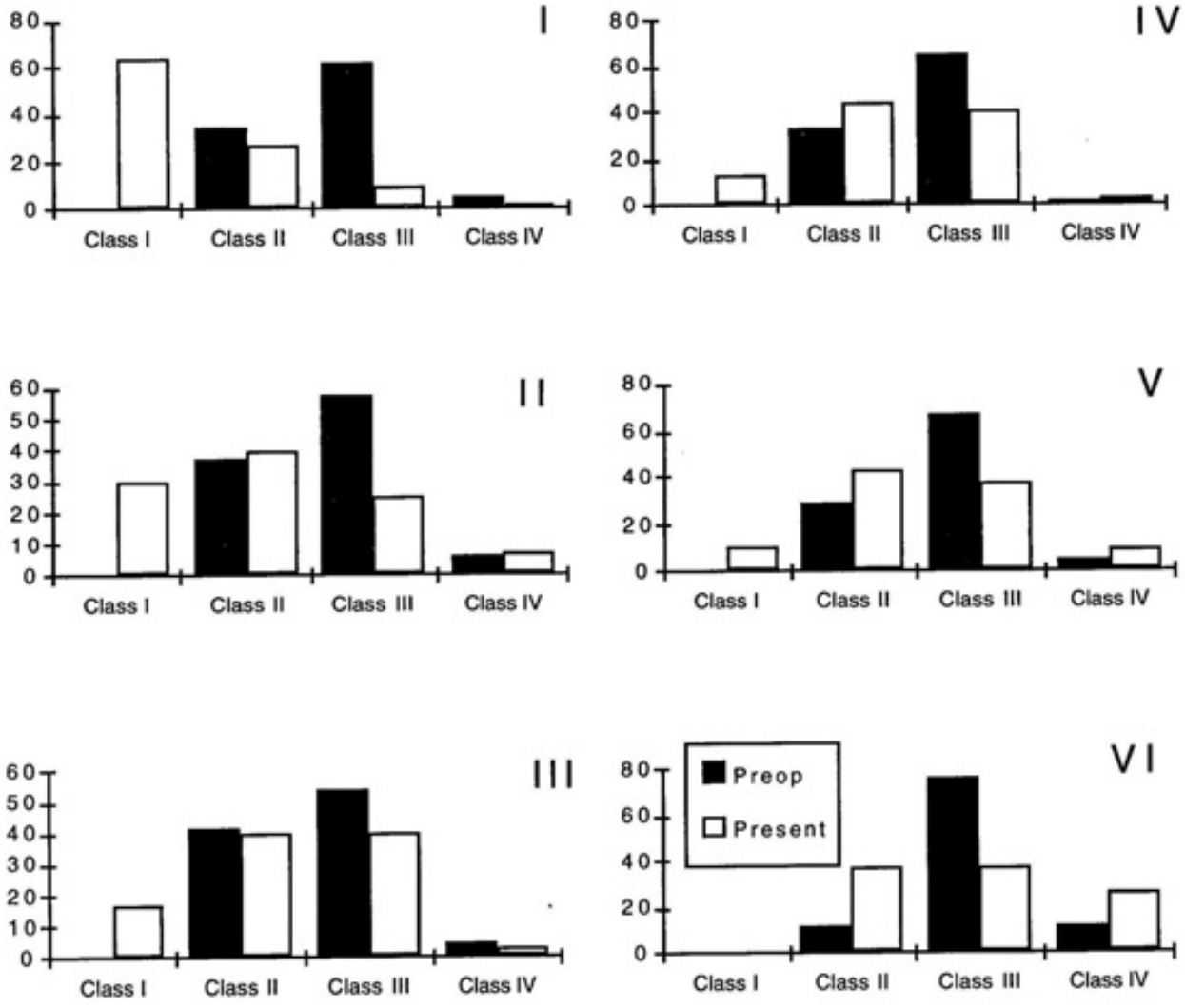


**Figure 1.** New York Heart Association (NYHA) functional classes and comparison of the patients during the presentation and preoperation period.

**Table 3.** Mitral valve areas and mitral valve gradients of six groups

| Group | MVA mean ± SD | MVG mean ± SD |
|---|---|---|
| Group I | 1.50 ± 0.6 | 7.21 ± 4.13 |
| Group II | 1.35 ± 0.39 | 8.84 ± 4.13 |
| Group III | 1.48 ± 0.71 | 8.77 ± 5.03 |
| Group IV | 1.32 ± 0.44 | 8.70 ± 4.2 |
| Group V | 1.21 ± 0.38 | 8.40 ± 5.04 |
| Group VI | 1.00 ± 0.22 | 10.6 ± 8.5 |

MVA: Mitral valve area, MVG: Mitral valve gradient, MVA in group I are significantly larger than in Groups V or VI, and similarly MVG's are lesser ($p<0.05$).

**Table 4.** Classification according to the degree of mitral stenosis.

| Group | MVA ≥ 1.5 cm 2 | | MVA = 1.5-1.1 cm2 | | MVA≤1.1 cm2 | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| Group I | 45 | 59 | 20 | 26 | 11 | 15 |
| Group II | 50 | 44 | 22 | 20 | 41 | 36 |
| Group III | 48 | 39 | 30 | 25 | 44 | 36 |
| Group IV | 23 | 38 | 15 | 24 | 23 | 38 |
| Group V | 7 | 33 | 5 | 24 | 9 | 43 |
| Group VI | -- | 0 | 4 | 50 | 4 | 50 |

MVA: Mitral valve area.
Patients with MVA ≥ 1.5 cm2 was 59% in Group I, onthe other hand it become 0% in Group VI. Moreover, patients with MVA ≤1.1 cm2 was 15% in Group I and 50% in Group VI.

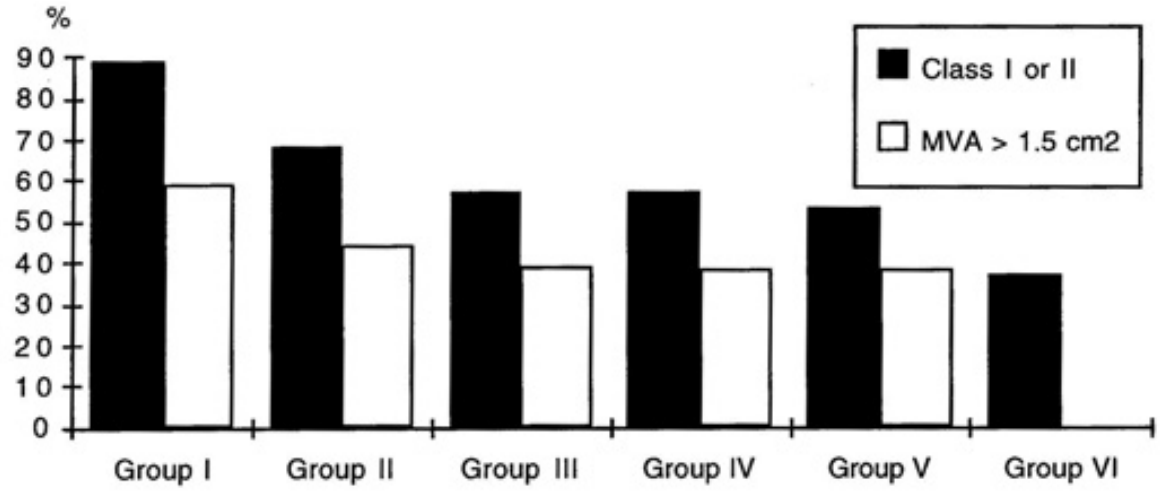


**Figure 2.** The distribution of echocardiographically and clinically successful cases. Clinical success is significantly higher than the echocardiographic success in group I, II and III ($p < 0.05$).

found between severe restenosis and clinically poor cases (p>0.05)(Figure 3). Number of cases with atrial fibrillation, the size of their left atrium, their echo scores, number of cases with mitral regurgitation higher than Grade II and with tricuspid regurgitation, their mean pulmonary arterial pressures during the presentation time are shown in Table 6.

**Table 5.** The comparison of cases which were echocardiographically and clinically unsuccessful.

| Group | Class III or IV (%) | MVA < 1.5 $cm^2$ (%) |
|---|---|---|
| Group I | 11 | 41 |
| Group II | 32 | 56 |
| Group III | 43 | 61 |
| Group IV | 43 | 62 |
| Group V | 47 | 67 |
| Group VI | 63 | 100 |

The percentage of echocardiographically restenosed cases were significantly higher than the percentage of clinically unsuccessfull case groups I, II and III (p<0.05).

**Table 6.** Other clinical and hemodynamical characteristics of the patients.

| Group | AF n | LA(cm) mean ±SD | Echo score mean ±SD | MR≥GrII | PAP (mmHg) |
|---|---|---|---|---|---|
| Group I | 42 | 5.5 ± 1 | 8 ± 2 | 5 | 48.2 ± 16.7 |
| Group II | 68 | 5.6 ± 0.9 | 7.1 ± 2.7 | 25 | 46.3 ± 24 |
| Group III | 79 | 5 ± 1.1 | 8.2 ± 2.3 | 16 | 48.5 ± 17.5 |
| Group IV | 37 | 5.1 ± 1.3 | 7.7 ± 2.5 | 10 | 47.9 ± 21.8 |
| Group V | 17 | 5.7 ± 1 | 9.3 ± 2.2 | 8 | 46.3 ± 15.5 |
| Group VI | 7 | 6.1 ± 1.9 | 11 ± 2.9 | 2 | 43.7 ± 12.1 |

AF: Atrial fibrillation, LA: left atrial diameter, MR ≥ Gr. II: Mitral regurgitation higher than Grade II, PAP: Systolic pulmonary arterial pressure.

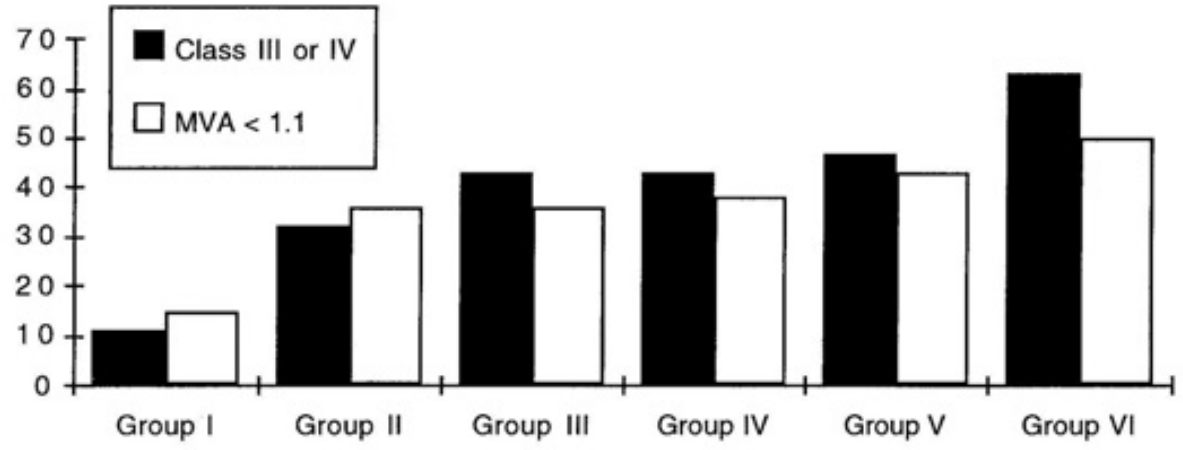


**Figure 3.** The distribution of cases with severely restenosed valves and poor clinical status. No statistically significant difference could be found between severely restenosed and clinically poor cases. (p > 0.05).

Pre and peri-operational calcification were detected in 25% of the patients. Mean MVA of the cases with calcified and noncalcified valves and rates of restenosis are given and compared in Table 7. Whereas the mean MVA value in calcified valves was 1.2±0.4 $cm^2$, this value was found 1.5±0.5 $cm^2$ in noncalcified cases ($p<0.0001$).

Percentage of cases with echocardiographically restenosed valve areas measured below 1.5 $cm^2$ was 77% in patients with calcified valves, whereas this percentage was 50% for patients with non-calcified valves ($p<0.0001$).

The distribution of calcified valves according to the groups and the rate of occurrence of restenosis were found similar ($p>0.05$) (Figure 4).

## DISCUSSION

Despite the fact that open mitral comissurotomy is preferred to CMC in the treatment of MS since 1960s, It has also been reported that, CMC does not constitute any higher risk related to mortality, requirement for a second mitral comissurotomy or MVR, thromboembolism, and functional status compared to open mitral comissurotomy [11]. In addition, in recent years it is believed that the major predictor of prognosis is the morphological structure of the mitral valve rather than the chosen technique[11]. PBMV, performed since 1983, is a technique similar to CMC. It has been reported that since the short term results are similar to the ones with CMC,

**Table 7.** Mean mitral valve areas of cases with calcified and uncalcified valves.

| **Valvular morphology** | **n** | **MVA<1.5 cm2** | | **MVA** |
|---|---|---|---|---|
| | **Total** | **n** | **(%)** | **mean ± SD** |
| Calcific valve | 100 (25%) | 77 | 77 | 1.2 ± 0.4 |
| Noncalcific valve | 301 (75%) | 151 | 50 | 1.5±0.5 |
| | | p<0.0001 | | p<0.0001 |

Both the percentage of restenotic cases and mean MVA's were significantly higher in calcific valves when compared to noncalcified valves ($p<0.0001$).
MVA:mitral valve area.

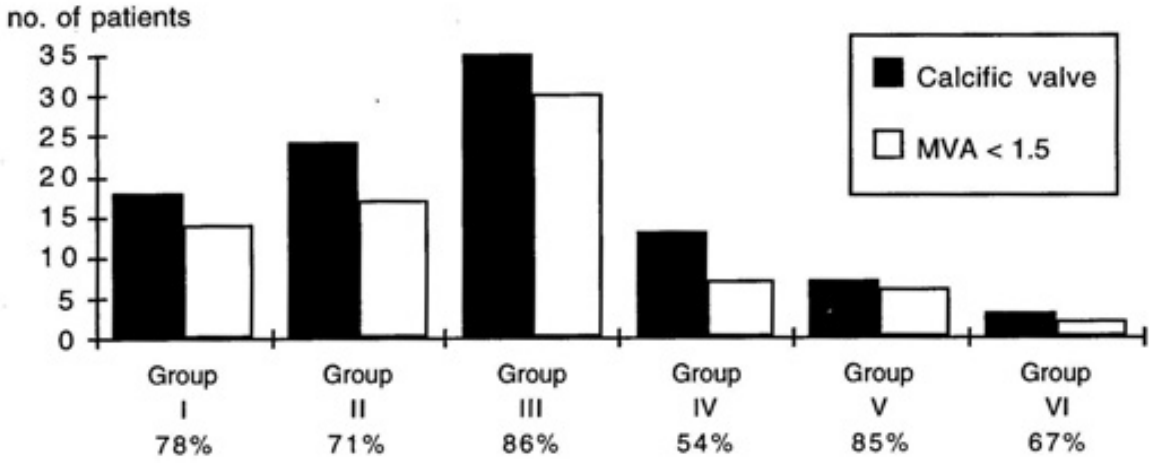


**Figure 4.** The distribution of patients with calcified and estenosed valves. The distribution of calcified valves according to the groups and the rate of occurrence of restenosis were found similar ($p>0.05$).
MVA: mitral valve area.

they are also expected to be similar in the long term follow-up[7,12-24]. On the other hand, both open comissurotomy and PBMV, are rather expensive procedures compared to CMC for our country. As shown in Table 8, in our center, CMC costs 1/3 less than PBMV. This value may give CMC the chance of being the first choice of application in treating the problem of rheumatic mitral stenosis in Turkey, since this disease is commonly seen in our country.

In the literature, follow-up studies after CMC generally are evaluated from the clinical point of view [24-31]. In our study we have evaluated our patients according to their echocardiographic findings. We have observed echocardiographically that mitral valve areas decreased with time, the rate of restenosis increased, and criteria for echocardiographic restenosis were not always parallel to clinical restenosis. It has also been observed that, clinical success was higher than echocardiographical success. Severe restenosis correlated with poor clinical status. This gives us the impression that the patient can maintain clinically well status, unless the valve area decreases below 1.1 $cm^2$.

We considered that, the turbulent flow and the ongoing fibrotic process lead to restenosis. Suboptimal results with CMC and rheumatic reactivation constitute the other causes of restenosis[32-34]. We do not consider these factors as the cause of restenosis, since only the cases with effective operation and without post operative rheumatic re-activation's after CMC were included in the study.

In this study, patients with MVA's of 1.5 $cm^2$ or more were accepted as echocardiographically successful. This criterion was agreed upon before starting this study due to the fact that patients with mitral valve areas of 1.5 $cm^2$ or more were regarded as having mild stenosis, and they were partially asymptomatic. PBMV studies with MVA≥1.5 $cm^2$ is regarded as a sufficient criterion for good results. It has been pointed out that the valvular structure is the most important factor for determining the early and the long term success in numerous BMV studies [7,14-24].

It's also a well known fact, that in calcified valves the success rate of CMC diminishes both in early and long-term periods [25-27,31-35]. In our study, we have observed that occurence of restenosis in early and also late periods were in a higher ratio in the calcified cases compared to non-calcified ones.

Limitation of the study:

This study was not planned for follow-up of every patient with CMC. The study cohort consisted solely of the patients who visited the echocardiography department for a check-up in a given period of time. Thus only 5.5% of the patients who had undergone CMC are covered in this study. This study was not

**Table 8.** Total costs for percutaneous balloon mitral vavotomy and closed mitral commissurotomy.

| | **PBMV** | **CMC** |
|---|---|---|
| Hospital room | 120$ (2 day) | 240 $ (4 day) |
| Cat. lab or operating room | 426$ | 365$ |
| Cardiogist or surgeon | - | - |
| Disposable | 2440$ | 244$ |
| Other(Drug etc..) | 122$ | 244$ |
| **Total** | **3108$** | **1093$** |

This table shows in hospital cost of PBMV (percutaneous balloon mitral valvotomy) and CMC (closed mitral commissurotomy) in our center. PBMV is approximately 3 times more expensive than CMC (approximately 3000$ versus 1000$) due to utilization of disposable materials.

planned as a survey investigation. There are already numerous publications reporting the early and late CMC results. Our study group represented a group of patients after CMC and an echocardiographic examination have been done. Thus it might be regarded as a good sample to determine the relation between the time interval from CMC to presentation and, the clinical and echocardiographical results of CMC. Except of group I patients, preoperative determination of MVA could not be done and these patients were referred to surgery after their clinical evaluation. However, perioperative digital evaluation of their valves confirmed that there was significant stenosis in these patients.

Thus CMC provides prominent and prolonged clinical success depending on time elapsed from the procedure. During the first 5 years, 89% were in a good functional status as opposed to only 37% beyond 30 years. Patients were observed to be in a good functional status unless MVA became ≤1.1 $cm^2$. MV calcification played an important role on restenosis.

In conclusion, CMC is a simple and less costly procedure which could be performed in appropriate cases after echocardiographic evaluation in countries where the rheumatic MS is still common.

## REFERENCE


1. Aggarwal BL: Rheumatic heart disease unabated in developing countries. Lancet 1981;1:910-911.
2. Strasser T: Community control of rheumatic heart disease in developing countries: A major public health problem. WHO Chron 1980;34:336-345.
3. The Criteria Committee of theNewYork Hearth Association Disease of the Heart and Blood Vessels: Nomenclature and criteria for Diagnosis, ed 6. Boston, Little, Brown &Co, 1964.
4. Libanoff J, Rodbard S: atrioventricular pressure half-time: Measure of mitral valve orifice area. Circulation 1968;38:144-150.
5. Hatle L, Angelson B, Tromsdal A: Noninvasive assesment of atrioventricular pressure half-time by Doppler ultrasound. Circulation 1979;60:96-104.
6. Wilkins GT, Weyman AE, Absacal VM, et al: Percutaneous balloon dilatation of the mitral valve: An analysis of echocardiographic variables related to outcome and the mechanism of dilatation. Br Heart J 1988;60:299-308.
7. Palacious IF, Block PC, Wilkins GT, Weyman AE: Follow-up of patients undergoing percutaneous mitral ballon valvotomy. Analysis of factors determining restenosis. Circulation 1989;79:573-579.
8. Miyateke K, Izumi S, Okamoto M, et al: Semiquantitative grading of severity of mitral regurgitation by realtime two dimensional Doppler flow imaging techniques. J Am Coll Cardiol 1986;7: 82-88.
9. Gerami S, Messmer BJ, Hallman GL, Cooley DA: open mitral comissurotomy: Results of 100 consecutive cases. J Thorac Cardiovasc Surg 1972;62:366-368.
10. Mullin MJ, Engelman RM, Isom OW: Experience with open mitral comissurotomy in 100 consecutive patients. Surgery 1974;76:974-982.
11. Hickey MSJ, Blackstone EH, Kirklin JW: Outcome probabilities and life history after surgical mitral commissuro-tomy: Implication for balloon commissurotomy. J Am Coll Cardiol 1991;17:29-42.
12. Lock JE, Khalılullah M, Shrıvastava S, et al: Percutaneous catheter commissurotomy in rheumatic mitral stenosis. N Engl J Med 1985;313:1515-1518.
13. Roccihini AP, Kveselis DA, Snider AR, et al: Balloon angiopalsty for the treatment of mitral stenosis (abst). Circulation 1985;72(suppl III):III-259.
14. Desideri A, Vanderperren O, Serra: Long term echocardiographic follow-up after successful percu-taneous mitral comissurotomy. Am J Cardiol 1992;69:1602-1606.
15. NHLBI Balloon Valvuloplasty Registry Report on Immediate and 30-Day Follow-up results: multicenter experience with balloon mitral comissurotomy. A report from the National Heart, Lung, and Blood

Institute Balloon Valvuloplasty Registry. Circulation 1992;85:448-461.
16. Vahanian A, Michel PL, Cormier B, et al: Results of percutaneous mitral comisurotomy in 200 patients. Am J Cardiol 1989;63:847-852.
17. McKay RG, Lock JE, Safian RD: Balloon dilation of mitral stenosis in adult patients: Postmortem and percutaneous mitral valvuloplasty studies. J Am Coll Cardiol 1987;9:727-731.
18. Reid CL, McKay CR, Chandraratna PAN, Rahimtoola SH: Mechanism of increase in mitral valve area and influence of anatomic features in double balloon, catheter balloon valvuloplasty in adults with rheumatic mitral stenosis: a Doppler and two-dimensional echocardiographic study. Circulation 1987;76:628-636.
19. Block PC, Palacios IF, Jacobs ML, et al: Mechanism of percutaneous mitral vavotomy. Am J Cardiol 1987;59: 177-178.
20. Davidson CJ, Bashore TM, Mickel M, et al: Balloon mitral comissurotomy after previous surgical commissurotomy. Circulation 1992;86:91-99.
21. Abascal VM, Wilkins GT, O'Shea JP: Prediction of success in 130 patients undergoing percutaneous balloon mitral valvotomy. Circulation 1990;82:448-456.
22. Zaibag MA, Ribeiro PA, Kasab SA: One year follow-up after percutaneous double balloon mitral valvotomy. Am J Cardiol 1989;63:126-127.
23. Block PC, Palacios IF, Tuzcu EM: Late (two-year) follow-up after percutaneous balloon mitral valvotomy. Am J Cardiol 1992;69:537-541.
24. Turi ZG, Reyes PR, Raju BS: Percutaneous balloon versus surgical closed commissurotomy for mitral stenosis: A Prospective randomized trial. Circulation 1991;83:1179-1185.
25. John S, Bashi VV, Jairaj PS: Closed mitral valvotomy: Early results and long-term follow-up of 3724 consecutive patients. Circulation 1983;68:891-896.
26. Ellis LB, Harken DE: Closed valvuloplasty for mitral stenosis: A twelve year follow-up study of 1571 patients. N Engl J Med 1964;270:643-650.
27. Grantham RN, Daggett WM, Cosimi AB: Transventricular mitral valvotomy: Analysis of factors influencing operative and late results. Circulation 1974;49-50(suppl II):II-200-II-211.
28. Ellis LB, Singh JB, Harken DE: Fifteen-to-twenty-year study of one thousand patients undergoing closed mitral valvuloplasty. Circulation 1973;48:357-364.
29. Holmes DR, Frye RL, Nishimura RF: Long-term follow-up of patients undergoing closed transventricular mitral valve commissurotomy (abst). J Am Coll Cardiol 1989;13(suppl A): 18A.
30. Commerford PJ, Hastie T, Beck W: Closed mitral valvotomy actuarial analysis of results in 654 patients in 12 years and analysis of preoperative predictors of long-term survival. Ann Thorac Surg 1982;33:473-479.
31. Molajo AO, Bennett DH, Bray CL: Actuarial analysis of late results after closed mitral valvotomy. Ann Thorac Surg 1988;45:364-369.
32. Higgs LM, Glancy DL, O'Brien KP: Mitral restenosis:uncommon cause of recurrent symptoms following mitral commissurotomy. Am J Cardiol 1970;26:34-37.
33. Harken DE, Black H, Taylor WJ: Reoperation for mitral stenosis: A discussion of postoperative deterioration and methods of improving initial and secondary operation. Circulation 1961;23:7-12.
34. Dekker A, Black H, vonLichtenberg F: Mitral valve restenosis. A pathologic study. J Thorac Cardiovasc Surg 1968;55:434-446.
35. Fraser K, Turner MA, Sugden BA: Closed mitral valvotomy. Br Med J 1976;2:352-353.