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Long term Outcome Of Extended Surgical Septal Myectomy With Mitral Valve Preservation For Hypertrophic Obstructive Cardiomyopathy With Moderate To Severe Mitral Regurge

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ABSTRACT

Background: HCM is an autosomal dominant complex disease and considered the commonest cause of sudden cardiac death. Hypertrophic cardiomyopathy frequently associated with left ventricular outflow tract (LVOT) obstruction. It is clearly demonstrated that this is due not only to septal hypertrophy but also to systolic anterior motion (SAM) of mitral valve leaflets secondary to mitral valve/subvalvular apparatus abnormalities. Surgical treatment involves performing an extended septal myectomy which is the gold standard for relief of outflow tract obstruction and SAM.

Patients & Methods: This retrospective study in Kasr Alainy Hospital in the period of January 2000 until December 2023 included 40 patients who had HOCM with moderate to severe mitral regurgitation were scheduled for extended septal myectomy using on pump method, patients were selected with septal wall thickness ≥ 1.5 cm in adults and Resting or provoked peak systolic LVOT gradient of 50 mmHg or more. Specimens were examined for any histopathological changes &patients were followed up by clinical examination &investigations during surgery, ICU stay, hospital stay &follow up periods data collected and analyzed in comparison with pre-operative data as well as at these different follow up periods.

Results: Mean age was (37.93±16.13), with 52.5% males. All patients suffered from dyspnea FC III, IV despite maximally tolerated medication. Family history of HCM was positive in 27.5%. Pre-operative mean PG was (105.8±22.9) mmHg, mean SWT was (2.30±0.66) cm, and 100% have moderate to severe MR. Intra-operative assessment showed significant reduction of PG to (14.27±8.32). mmHg, and 72.5%free of MR and only 25% have only mild MR. There was also significant improvement in 92.5% of SAM, clinical improvement in dyspnea FC. With 4 deaths at mean follow up period (3.67±5.2) ranges from 1-21 years. All survivors showed sustained clinical and echocardiographic improvements without recurrence of obstruction or SAM

Conclusions: We concluded that Extended myectomy is sufficient and efficient in treatment of HOCM and associated SAM &mitral regurgitation with preservation of mitral valve keeping replacement only for patients with intrinsic mitral valve abnormalities.

Keywords: *HOCM, SAM, PG, LVOT, septal myectomy*

1. INTRODUCTION

Left ventricular hypertrophy without sign of any cardiac, metabolic, or systemic illness is the hallmark of hypertrophic cardiomyopathy (HCM). The threshold for diagnosis is a myocardial wall thickness of 15 mm or more, measured at any point in the left ventricle (Ommen et al., 2020).

Asymmetric septal hypertrophy involving the septum from the base to the apex of the left ventricle is a common feature in HCM variations. Nonetheless, whether or not an obstruction is present, a wide variety of phenotypes can be observed (apical, concentric, lateral wall, & right ventricular) As stated by various researchers (Ommen et al., 2020).

Genes encoding proteins of the cardiac sarcomere or structures linked to it are associated with the autosomal dominant inheritance of hypertrophic cardiomyopathy (HCM). It is unclear how exactly the genetic change causes myocyte disarrangement, fibrosis, and hypertrophy to create a defective structure (Jones & Zweier, 2014). As reported by (Schwartz and Mercadier, 2003).

However, for the vast majority of HCM patients, no underlying genetic change or family history of the disease can be established (termed "non-familial HCM")

As a result, it is possible that pathophysiologic processes other than those previously considered are responsible for the disease's clinical manifestation (Ingles et al., 2017).

2. AIM OF THE WORK

Assess the long-term results of treating cases with HOCM who have moderate to severe mitral regurge using only extended septal myectomy and no mitral valve repair.

3. PATIENTS AND METHODS

In this retrospective study, 40 symptomatic patients with hypertrophic obstructive cardiomyopathy underwent trans-aortic Extended septal myectomy, to evaluate the early, mid-term and long-term results of septal myectomy for HOCM disease in a sample of patients were identified from the database of Kasr Alainy Hospital between January 2000 and December 2023.

Inclusion criteria:

Any patient (40) at any age with (HOCM) who has all of following: Symptoms refractory to maximal medical treatment. Resting or provoked peak systolic LVOT gradient of 50 mmHg or more. Targeted septal wall thickness sufficient to perform the procedure safely and effectively (septal wall thickness ≥ 1.5 cm) in adults. With moderate to severe mitral regurge due to systolic anterior motion (SAM).

Exclusion criteria*:* HOCM associated with ischemic or rheumatic heart disease. HOCM associated with myocardial bridge which indicated for surgical revascularization.

Methods:

Preoperative Parameters:

History taking: A thorough and detailed history is taken with special emphasis on demographic data (age and gender), symptoms (dyspnea,syncope, palpitation and angina),type of medication used,pre-operative general risk factors for major surgery; past history of (previous cardiac surgery, liver diseases, renal diseases, diabetes mellitus (DM) and/or morbid obesity) and family history of similar conditions or sudden cardiac death.

Clinical examination: A complete clinical examination both general and local cardiological were performed.

Investigations: Routine laboratory investigations (Labs); complete blood picture, liver and kidney functions, serum electrolytes level, coagulations profile and fasting blood sugar. Radiological examination; chest X-ray (postero-anterior). Electrocardiogram (ECG): 12- Lead ECG was done with the aim of: Record the basic rhythm of the patient whether sinus or A.F. Detect any preoperative conduction disturbances (Presence of LBBB, heart block and its degree)

Echocardiography: to evaluate the following parameters: Left ventricular dimensions and function, LVOT peak systolic gradients at rest and with physiological provocation, interventricular septal wall thickness (SWT). Mitral valve structure including presence of MR, its degree and presence of systolic anterior motion (SAM) and its degree. Presence of AR, its degree if present and left atrial (LA) diameter.

Preoperative preparation;

All patients underwent routine preoperative preparation in the ward the night before operation by shaving, washing of the body is done with washing povidone-iodine topical antiseptics. Premedication are given including prophylactic intra-venous (IV) antibiotics, IV antacid and intramuscular 10-mg morphine sulphate before transfer to the operating theatre.

Intra-Operative Procedures:

After induction of general anesthesia and placement of routine monitoring lines, transesophageal echocardiography (TEE) is performed. A standard median sternotomy is preferred. We routinely measure simultaneous aortic and left ventricular pressures after aortic cannulation and before placement of the venous cannula, a full heparinization protocol was given to maintain activated clotting time (ACT) between 400-450 sec.

We favor normothermic cardiopulmonary bypass using a single, 2-staged venous cannula and cold blood cardioplegia with an initial dose of 1000-1200 ml to arrest and cool the hypertrophied ventricle.

Adequate exposure of the subaortic septum is critically important, and several maneuvers facilitate the operation. Pericardial sutures are used only on the right side to elevate pericardium toward the surgeon and allow the left ventricle to fall posteriorly in the thorax. Next, an oblique aortotomy is made slightly closer to the sinotubular ridge than is usual for aortic valve replacement, and the incision is carried through the mid point of the noncoronary aortic sinus of Valsalva to a level approximately 1 cm above the valve annulus.

All three commissures of the aortic valve are pulled up with 4-0 prolene stay sutures that are tightly fixed to the sides of the sternotomy for better exposure. A small curved aortic retractor is inserted anteriorly into the right coronary sinus to improve exposure,or a cardiotomy sucker is placed through the aortic valve and used to depress the anterior leaflet of the mitral valve and protect it from injury.

Visibility of the septum is also improved by gentle pushing of the lateral surface of the heart with a swab on a stick. At this stage the LV cavity is explored to check the presence of any subaortic membrane or septal endocardial fibrosis at the site of contact with anterior mitral leaflet. Sometimes a 4-0 prolene fixation stitch is taken in the hypertrophied sputum approximately 8 to10 mm below the aortic valve and pulled to facilitate visualization and excision of the hypertrophied septum.

Using a 15 blade scalpel, two parallel longitudinal incisions are made; the first incision starts about 3 mm below the aortic annulus at the level of the right coronary ostium to be safe away from the bundle of His. The other line is made below the commissure between right and left coronary cusps of. Both incisions are extended downwards into the LV cavity as could be seen and about 0.5 to 1 cm deep into the septum. A transverse incision is made into the septum between the two longitudinal incisions, about 3 to 5 mm underneath and parallel to the aortic valve annulus. The incision is then deepened with a scissor carefully and not so deep to avoid inducing VSD.

. It is important to excise this first and major portion of the septum in one single piece, because further resection from the myocardial muscle is difficult. The incision is then extended downward toward the base of the anterior papillary muscle. In general, the thickness of the resected muscle is two-thirds the thickness of septum (as measured by prebypass TEE images), while ensuring that the retained septum is at least 1 cm thick.

Extended septal myectomy is completed by excision of the lower posterior part of the septal bulge, which is done by another incision that is made about 1½ - 2 cm below the lower rim of the membranous septum in order not to damage the bundle of His. The incision is made in an oblique direction and joins the trough previously created. This step allows an additional triangular excision of the lower posterior septum.

The excision stops just above the base of the papillary muscles. Also any fibrous peel found over the septum facing the anterior mitral leaflet is peeled off.

Figure (1): Muscles excised after septal myectomy.

Release of the both fibrous trigones is an integral part of effective surgery in cases of obstructive HCM as described by ***Yacoub***. On the left side, further excision of a piece of the septum beyond the commissure between the right and left aortic cusps to open the acute angle between the septum and the anterior mitral leaflet just before the left fibrous trigone may be needed. There may be excessive fibrous tissue formation at this spot which may need blunt or sharp dissection and even careful excision. The same maneuver may be needed to release the right fibrous trigone.

Trabeculations and abnormal chordae are excised, and the myectomy site is further enlarged using pituitary rongeurs. Adequate septal myectomy usually yields 3-12 g of muscle. Depressing the heart posteriorly with a sponge stick will improve exposure of the distal extent of the myectomy. If the papillary muscles are hypertrophied or adherent to the septum, they must be freed to allow free mobility.

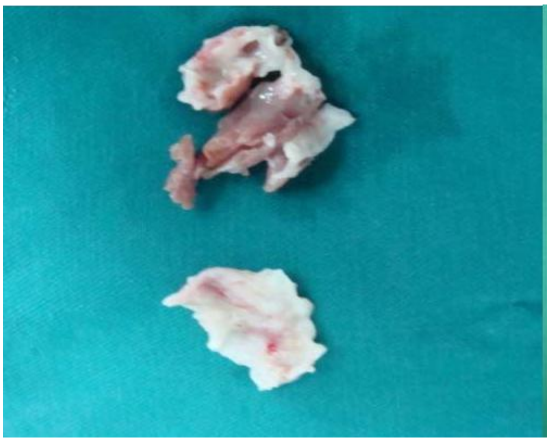

Figure (2): Muscles excised after septal myectomy.

Also any abnormal muscle band attaching the anterior mitral leaflet to the septum is excised. Direct inspection and digital palpation evaluate the adequacy and distal extent of the resection (Fig. 3).

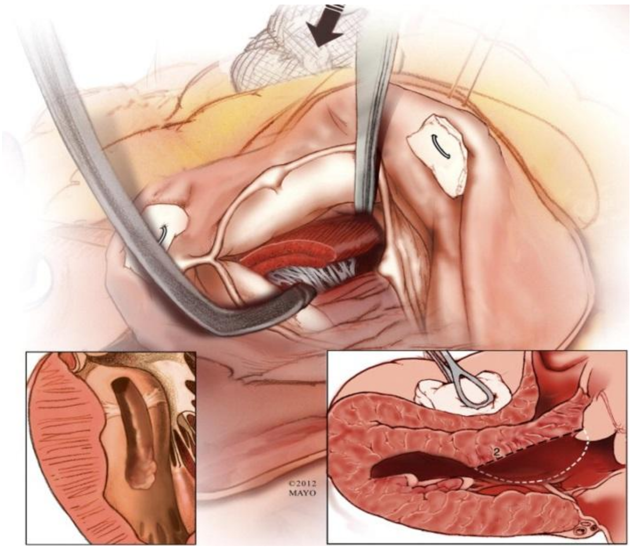

Figure (3): The completed left ventricular septal myectomy *(Schaff and Said, 2012)*.

The most common reasons for residual gradients are inadequate septectomy at midventricular level and overlooked anomalous papillary muscles. In general, one can visualize the papillary muscles and chordae while looking through the aortic root after the myectomy has been completed. The aortic and mitral valves are inspected to insure that there has been no injury to them.

Inadequate myectomy results more often from failure to excise a sufficient length of the septum (toward the apex) than from inadequate depth of excision. Importantly, and maneuvers, such as anterior leaflet plication are unnecessary and, we believe, potentially harmful. Mitral valve replacement is reserved for patients with intrinsic leaflet abnormalities that cannot be repaired.

To confirm complete relief of the LVOT obstruction, we repeat measurement of simultaneous aortic and left ventricular pressure by direct needle puncture after myectomy after the patient is weaned from cardiopulmonary bypass. In most patients there will be no residual gradients after myectomy and near complete elimination of systolic anterior motion (SAM).

If residual gradients of more than 15 mm Hg would prompt resumption of cardiopulmonary bypass and further excision of septal muscle. TEE is repeated to confirm relief of LVOT obstruction, identify obstruction at any other level, and confirm that there is no ventricular septal defect or injury to the aortic valve.

Accessory papillary muscle that arises from the ventricular septum. The fibrous attachments to the side of the anterior mitral leaflet can be seen. Anomalous papillary muscles may contribute to LVOT obstruction and can be safely excised (dotted line) if the point of insertion is not on the free margin of the leaflet (figure 4).

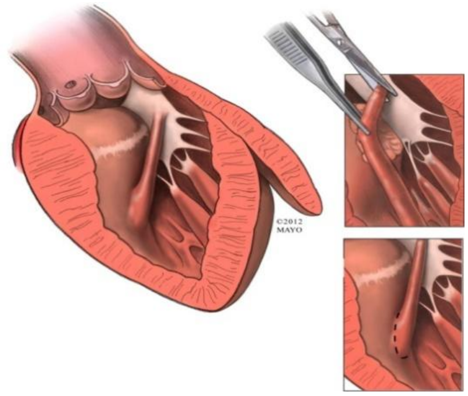

Figure (4): Accessory papillary muscle)attached to septum ***(Schaff and Said, 2012).***

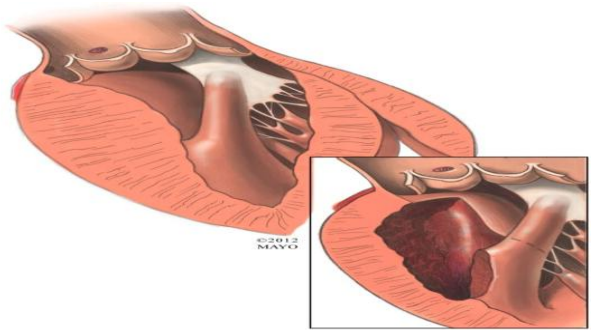

Figure (5): Direct insertion of the head of the anterolateral papillary muscle into the anterior leaflet of the mitral valve may contribute to outflow obstruction. The muscle insertion site is frequently adjacent to the commissure of the mitral valve. In addition there is often concomitant fusion of the papillary muscle to the left ventricular septum or free wall ***(Schaff and Said, 2012).***

Aortotomy is then closed by two running 4-0 or 5-0 prolene sutures starting from either ends of the incision to meet at the midpoint of the incision in a single layer.

A piece of the excised muscle is routinely sent for histo-pathological examination to confirm the diagnosis of HCM.

Intra-operative Parameters:

The following data are recorded for statistical analysis:

LV outflow gradient after myectomy measured by instantaneous pressure measurement of the left ventricle and radial artery, pull-back technique and/or intra-operative TEE (if available). If there were any complications (iatrogenic VSD, AR or CHB). Haemodynamics including: blood pressure, heart rate, central venous pressure and urine output. Patient's rhythm during going off bypass and on transfer from the operating theatre and also if there are any conduction deficits.

Postoperative Parameters:

Immediate post-operative follow-up (within hospital stay and up to one month after surgery): Postoperative intensive care unit (ICU) stay: ECG is done on admission to the ICU to record the baseline rhythm of the patient and to detect any conduction disturbances. Also anther ECG is done on discharge from the ICU. In case of arrhythmia, daily ECG is done to follow up the patient's rhythm. Any post-operative complications, and the need for temporary or permanent cardiac pacing. Immediate (pre-discharge) assessment:

Routine postoperative follow up is done to record hemodynamics, post-operative Labs and complications. Twelve-lead ECG is done, if there are any ECG changes or arrhythmias compared to previous ECGs. Also, chest X- ray is done.

All patients are assessed for symptomatic improvement especially dyspnea functional class just before discharge. Also, a postoperative trans-thoracic echocardiography is performed before discharge to evaluate the following parameters; LVOT peak systolic gradients, Interventricular septal wall thickness. Persistence of systolic anterior motion (SAM) or not. presence of residual MR and its degree. Presence of post-operative aortic incompetence or VSD, and Left atrial diameter.

Post-operative protocol of medical therapy:

In adults, we usually start with B-blockers (bisoprolol 5 mg daily per oral) and depending upon the patient's response and clinical status, the dose can be increased gradually if needed. In patients who are intolerant to B-blockers (as in patients with chest problems), we replaced b-blockers with Ca channel blockers (verapamil 80 mg twice or 3 times daily per-oral and also the dose is titrated gradually upon need). In patient with persistent symptoms, combination of the 2 drugs was tried.

Short-term follow-up (form 1–12 months after surgery):

Patients were seen after the first month of surgery up to the first year on 3-monthly basis or if there is any change in their clinical status or new cardiovascular event. At 6 months post-operatively, patients were seen to assess clinical symptomatic improvement and to perform a trans-thoracic echocardiography to re-evaluate the previously mentioned parameters.

Mid-term Follow up (From 12 – 60 months):

Patients are seen 12 months after surgery and then on annual basis to assess clinical symptomatic status and to perform regular trans-thoracic echocardiography.

Long-term follow up (more than 60 months):

Assessment of clinical symptomatic status and trans-thoracic echocardiography data in patients who had more than 60 months passed after surgery (five year).

Statistical Analysis:

Data collected and coded to facilitate data manipulation and double entered into Microsoft Access and data analysis performed using the Statistical Package of Social Science **(SPSS)** software version 22 in windows 7 (SPSS Inc., Chicago, IL, USA). Simple descriptive analysis in the form of numbers and percentages of qualitative data, and arithmetic means as central tendency measurement, standard deviations as a measure of dispersion of quantitative parametric data.

4. RESULTS

Table (1): Description of demographic characters among study group.

(N0=40)	Mean	SD	Minimum	Maximum
Age (y)	37.93	16.13	10.00	64.00

(N0=40)		Count	%
Sex	**Male**	21	52.5%
	Female	19	47.5%

Table (2): Description of medical and family history among study group.

(N0=40)		Count	%
Medical History	**Negative(-ve)**	30	75.0%
	DM	2	5.0%
	HTN	6	15.0%
	RENAL	1	2.5%
	CHD	1	2.5%
Family History	**Negative**	29	72.5%
	Positive	11	27.5%
B.BLOCKER	**No**	6	15.0%
	Yes	34	85.0%
CA. chanel blocker	**No**	28	70.0%
	Yes	12	30.0%
Lab results	**No**	38	95.0%
	KFTS	1	2.5%
	LFTS	1	2.5%
ECG abnormality	**No**	35	87.5%
	Yes	5	12.5%

Table (3): Frequency of different complaint among study group.

(N0=40)		Count	%
SOB	**NYHA GRADE II**	5	12.5%
	NYHA GRADE III	32	80.0%
	NYHA GRADE IV	3	7.5%
Syncope	**No**	24	60.0%
	Yes	16	40.0%
Angina	**No**	20	50.0%
	Yes	20	50.0%
Palpitation	**No**	23	57.5%
	Yes	17	42.5%

Table (4): Preoperative echo-cardiographic assessment of cases.

(N0=40)		Count	%
PRE operative SAM	**No**	0	0.0%
	Yes	40	100.0%
PRE operative MR	**No**	0	0.0%
	MILD	0	0.0%
	MOD	31	77.5%
	SEVERE	9	22.5%
PRE operative AR	**No**	39	97.5%
	Yes	1	2.5%

	Mean	SD	Minimum	Maximum
PRE operative PG	110.48	27.70	50.00	164.00
PRE operative SWT	2.24	0.53	1.40	3.40

Table (5): Intra and immediately post-operative echo-cardiographic and clinical assessment of cases.

(N0=40)		Count	%
Immediate post operative SAM	**No**	37	92.5%
	Yes	3	7.5%
Immediate post operative MR	**No**	29	72.5%
	mild	10	25.0%
	moderate	1	2.5%
Immediate post operative AR	**No**	39	97.5%
	Yes	1	2.5%
Immediate post operative VSD	**No**	39	97.5%
	Yes	1	2.5%
Immediate post operative FC (dyspnea)	**negative**	38	95.0%
	Grade I	1	2.5%
	Grade II	1	2.5%

	Mean	SD	Minimum	Maximum
Intra-operative PG	8.45	4.87	0.00	20.00
Immediate post PG	14.27	8.32	2.00	40.00

Table (6): Different outcomes among cases.

(No=40)		Count	%
POST operative LBBB	**No**	18	45.0%
	Yes	22	55.0%
PACEMACKER	**No**	38	95.0%
	Yes	2	5.0%

Table (7): Short-term post-operative echo-cardiographic and clinical assessment of cases.

(N0=40)		Count	%
Short term post operative SAM	**No**	27	67.5%
	Yes	13	32.5%
Short term post operative MR	**No**	19	47.5%
	Mild	19	47.5%
	Moderate	2	5.0%
Short term post operative AR	**No**	38	95.0%
	Yes	2	5.0%

Short term post operative FC (dyspnea)	**No**	27	67.5%
	Grade I	12	30.0%
	Grade II	1	2.5%

	Mean	**SD**	**Minimum**	**Maximum**
Short term post operative PG	17.37	7.81	10.00	42.00

Table (8): Mid-term post-operative echo-cardiographic and clinical assessment of cases.

(N0=40)		**Count**	**%**
Mid term post operative SAM	**No**	30	75.0%
	Yes	10	25.0%
Mid term post operative MR	**No**	21	52.5%
	Mild	17	42.5%
	Moderate	2	5.0%
Mid term post operative AR	**No**	35	87.5%
	Yes	5	12.5%
Mid term post operative FC(dyspnea)	**Negative**	35	87.5%
	Grade I	5	12.5%
	Grade II	0	0.0%

	Mean	**SD**	**Minimum**	**Maximum**
Mid term post operative PG	18.10	9.53	8.00	52.00

Table (9): Long-term post-operative echo-cardiographic and clinical assessment of cases.

(N0=11)		**Count**	**%**
Long term post operative SAM	**No**	9	81.8%
	Yes	2	18.2%
Long term post operative MR	**No**	7	63.6%
	Mild	4	36.4%
	Moderate	0	0.0%
Long term post operative AR	**No**	8	72.7%
	Yes	3	27.3%
Long term post operative FC(dyspnea)	**Negative**	8	72.7%
	Grade I	3	27.3%

	Grade II	0	0.0%

	Mean	SD	Minimum	Maximum
Long term post operative PG	17.55	11.13	7.00	35.00

Table (10): Different mortality rate among cases.

		Count	%
Mortality	No	36	90.0%
	Yes	4	10.0%

	Mean	SD	Minimum	Maximum
Follow up Years	3.67	5.20	1.00	21.00

Table (11): Comparison of PG over time.

	Mean	SD	Minimum	Maximum	P value compared to pre
PRE PG	110.48	27.70	50.00	164.00	----
Intra-operative PG	8.45	4.87	0.00	20.00	<0.001
Immediate post PG	14.27	8.32	2.00	40.00	<0.001
Short term post PG	17.37	7.81	10.00	42.00	<0.001
Middle term post PG	18.10	9.53	8.00	52.00	<0.001
Long term post PG	17.55	11.13	7.00	35.00	<0.001

Table (12): Comparison of pre and post-operative echo-cardio graphic

		Pre-operative		Post (long term)		
		Count	%	Count	%	P value
SAM	No	0	0.0%	9	81.8%	0.004
	Yes	40	100.0%	2	18.2%	
MR	No	0	0.0%	7	63.6%	0.002
	MILD	0	0.0%	4	36.4%	
	MOD	31	77.5%	0	0.0%	
	SEVERE	9	22.5%	0	0.0%	
AR	No	39	97.5%	8	72.7%	0.250
	Yes	1	2.5%	3	27.3%	

Table (13): Comparison of immediate and long-term post-operative FC of dyspnea& echo-cardiographic assessment of cases

		Immediately post-operative		Post (long term)		
		Count	%	Count	%	P value
FC	Negative	38	95.0%	8	72.7%	1
	Grade I	1	2.5%	3	27.3%	
	Grade II	1	2.5%	0	0.0%	

Table (14): Kaplan-Meier survival among cases.

Mean survival time			
Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
16.397	2.408	11.677	21.117

5. DISCUSSION

The present study was undertaken In the Cardiothoracic Surgery Department, Kasr Alainy, Cairo University and its affiliated hospitals in the period between January 2000 and December 2023, to evaluate the early results and mid & long-term clinical and echocardiographic follow-up of extended septal myectomy in Forty patients with HOCM.

Pre-operative assessment;

The mean age among our group was (37.93±16.13) years old ranged between 10 and 64 years old, and 52.5% were males versus 47.5% were females. ***Talukder et al. (2020)*** who reported The mean age of patients was (37.85 ± 12.3) years ranges from (23-67), with patients (66.7%) were male; a mean of 12.9 years but this study was focused on children and young adults, so younger mean was excepted, ***Pruna-Guillen et al. (2021)*** reported mean age 71.5 (65–82) years this study focused on old patients (52patients).

Rastegar et al. (2017) reported mean age (52.1±14.3)this study included 482 patients, ***Wang et al. (2016)*** reported mean age 47(35-54) this study included 277 patients.

Preoperative symptoms: In our study as well as most of other studies the most common presenting symptom was dyspnea, with most of the patients in functional class III or IV (87.5%),(40%) of our cases presented by syncope, (50%) had angina, and (42.5%) had palpitation. The mean duration of symptom was (3.1±2.5) years ranged between 1 and 13 years.

Rastegar et al. (2017) reported dyspnea NYHA class III or IV (98%) Syncope (14.6%).

Talukder et al. (2020) reported that Heart failure symptoms consistent with (NYHA) class III/II were present preoperatively in (52%) of patients with mean (2.95 ± 0.38) based on personal functional capacity deficits, including exertional dyspnea or chest pain during daily work. No patient had NYHA class IV symptoms.

Wang et al reported exertional dyspnea in (93.86%), syncope (22.38%) stethalgia (41.88%), ***Pruna-Guillen et al. (2021)*** reported exertional dyspnea in (90.4%), Syncope (11.5%), angina in (40.4%).

Risk factors*:* 10 patients (25%) had general pre-operative risk factors for major surgery. The impaired renal functions before operation were also reported to affect the outcome of surgery. We had one patient with renal impairement who died in the postoperative follow up. We had 6 patients (15%) hypertensive.

Diabetes Mellitus especially if uncontrolled and *morbid obesity* can lead to wound infection and even sternal dehiscence and mediastinitis. In our study, 2 patients (5%) had DM.

Ji et al. (2020) also reported DM in (10%) of their patients, hypertension in (40%) as a pre-operative non- cardiac co-morbidity, while Robert ***Pruna-Guillen et al. (2021)*** reported diabetes mellitus in (25%), hypertension in (75%)of their patients this may differ from our study due to their higher age group of patients.

***Family history*:** The incidence of positive family history of HOCM varied in literatures. We had 27.5% of our patients with family history of Hocm. We agree with Wang et al who reported 52 patients (18.77%) with positive family history of Hocm and 38 patients (13.72%) with positive family history of SCD.

Rastegar et al. (2017) reported (24.3%) with positive family history of hocm and (8.6%) with positive family history of SCD.

This rather low incidence in our study, and other studies may be explained by deficient family screening of patients' families.

Risk of SCD:

Ventricular arrhythmia is the most serious presentation for which an ICD was implanted in one of our patients few years before operation. Other authors reported a higher incidence of ICD implantation due to available resources and better screening for need of ICD.

ECG: All HOCM patients showed ECG changes related to LVH & strain secondary to septal hypertrophy. However, some other abnormalities may be encountered and may influence prognosis. In our study,(87.5%) has normal sinus rhythm while (12.5%) had ECG abnormalities in the form of RBBB, AF, ventricular arrhythmia, temporary pacing.

Rastegar et al. (2017) reported pre operative AF in 180 patients (37.5%) while ***Pruna-Guillen et al. (2021)*** reported pre operative AF (25%).

We agree with Woo et al that AF carries a worse prognostic weight in terms of cerebrovascular and heart failure complications.

Ji et al. (2020) reported that (10%) had AF and (2.2%) had RBBB.

Cui et al. (2019) reported that (87.0%) had no LBBB, (4.4%) had LBBB, and (4.5%) had RBBB. The remaining (4.1%) had continuously paced rhythm before myectomy, for whom function of the conduction system was unknown. Those patients with RBBB are at higher risk to develop CHB in case of having LBBB after septal resection.

Preoperative echocardiographic assessment

Peak systolic gradient across LVOT*:* all our patients had a pre- operative LVOT PG ranged from (50-164) mmhg with mean was (110.48±27.7), which is a must for patients to be indicated for surgery according to guidelines (18).

Pruna-Guillen et al. (2021) reported mean pre- operative PG 80 (50–220)mmhg. ***Schleihauf et al. (2018)*** reported mean Pre- operative PG 78 (50–143) in patients from (1-18) years old, and PG 88 (62–146) in infants less than one year old. This suggests that higher gradients is not related to age, and even younger patients can show higher gradients (the highest gradient in our patients ≤18 years was 150 mmHg, which belonged to a 16 years old, which was higher than a lot of readings reported for much older patients in our study).

Pre operative SWT in our study ranged from (1.4-3.4) cm with a mean (2.24±0.53). ***Talukder et al. (2020)*** reported Pre - operative SWT (20.67 ± 3.86) mm, while Wang et al reported mean Pre operative SWT 19 (16-22)mm.(Wang et al., 2016) unlike ***Schleihauf et al. (2018)*** who reported mean Pre operative SWT 6.3 [4.3–8.1] in patients from (1-18) years old, and SWT 5.6 [2.8–7.9] in infants less than one years. ***Ji et al. (2020)*** reported mean Pre- operative SWT (16.4 ± 2.3) in the combined group, and (18.5 ± 3.2) in the alone group. Pruna-Guillen et al reported mean Pre operative SWT (26 ± 5).

SAM & mitral incompetence: As regards SAM, in our study 100%of patients had SAM. Also, in our study, 100% of the patients had moderate or severe MR.

Most of the studies reported similar results as Wang et al., reported 100% of the patients having SAM. They also reported similar results of pre-operative MR with 60% having moderate or severe MR.

Schleihauf et al. (2018) reported Pre -operative SAM in 80% of patients from (1-18) years old,(67%) in infants less than one year old. They also reported pre- operative moderate or severe MR (80%) in patients from (1-18) years old,and (50%) in infants less than one year old.

Talukder et al. (2020) reported pre-operative SAM (82.6%) 70% of patients had grade IV, and 13% of patients had grade III SAM with mean (3.67 ± 0.66),they also reported that preoperative MR mean (3.14 ± 0.73).

Pruna-Guillen et al reported mean pre operative SAM in 44 (84.6%) patients at rest and 52 (100%) patients with provocation, they also reported 69% of the patients had moderate or severe MR, ***Rastegar et al. (2017)*** reported pre-operative severe MR (7%) mild to moderate MR (63%), ***Ji et al. (2020)*** also reported 100% had SAM and the mean of pre-operative MR 3(2-3).

From all these data, it can be concluded that SAM is almost a constant finding in all patients, and the resulting MR is a common finding in the majority of the cases. In our study the percentage of patients with moderate or severe MR is higher than most of studies, indicating a significant SAM. These might help to explain the higher pre-PG in our patients as some of it is dynamic from the significant SAM.

Operative Data

Procedure: We adopted the trans-aortic extended Septal myectomy was performed in all the 40 patients without the need for additional mitral valve procedures.

Pruna-Guillen et al., reported that (84.6%) of patients had an extended SM and (15.4%) had a classic Morrow myectomy. Only (5.8%) patients required a combined transaortic and transapical approach to complete the resection and to enlarge the LV cavity, they also reported Additional LVOT Procedures (beyond Myectomy) for Obstruction Relief in 34 (65.4%) patients such as Secondary mitral valve chordae division, division of muscular connections to the ventricular septum, division of tendinous connections to the ventricular septum, anterior mitral valve leaflet horizontal plication, papillary muscle repositioning, papillary muscle relief, Fibrotic membrane resection and Trigonal release.

Wang et al reported that up to (54.15%) of their patients underwent myectomy alone and (45.8%) underwent concomitant cardiac procedures with myectomy.

Ji et al. (2020) reported that (72.3%) (131/181)patients underwent myectomy alone (27%) (50/181) patients underwent Myectomy plus subvalvular procedures.

Rastegar et al. (2017) reported in their retrospective study (72%) of their patients underwent isolated myectomy, mitral annuloplasty in (4.4%) patients, mitral valve replacement in 1 (0.2%) Other procedures in (5.2%) patients.

Intra-operative peak gradient measurement:

In this study, the mean post-myectomy intra-operative PG was (8.45±4.87) mmHg, which shows highly significant statistical difference when compared to the mean pre-operative PG of (110.48±27.7) mmHg (P value < 0.001). Maximum intra-operative gradient was 20 mmHg, with no patients requiring reinstitution of CPB for more extensive myectomy due to unacceptably high residual intra-operative gradient (more than 25 mmHg) only one patient needed repair of Iatrogenic VSD with dacron patch successfuly.

Ji et al. (2020) also reported significant reduction of gradient post- myectomy, with similar mean intra-operative PG of (11.9 ± 7.0) in myectomy alone group and (8.1 ± 5.2) in the combined group (myectomy and mitral subvalvular precedures).

They needed to Immediately repeat surgery in 10 (5.52%) patients in their study due to inadequate septal myectomy in 5 patients for further (extended myectomy and mitral valve repair in one patient by edge to edge technique, another patient by anterior leafleat enlargement using a patch, Left ventricular free wall rupture in 3 patients, Aortic valve perforation in 1 patient and septal perforation in 1 patient.

Minakata et al. (2004) reported lower post-myectomy intra-operative PG with a mean of (4.9 ± 8.4) mmHg shows highly significant statistical difference when compared to the mean pre- operative PG (70 ± 28) lower than most of other studies.

Talukder et al. (2020) reported that no patients needed reoperation for residual LVOT obstruction but Iatrogenic ventricular septal defect (VSD) was identified in 1 patient on perioperative TEE and was repaired.

Pruna-Guillen et al. (2021) reported that Two patients required a second cardiopulmonary bypass run to extend the resection, and in one also the papillary muscle was repositioned to fully relieve obstruction.

This shows the usefulness of intra-operative TEE, saving the patients from re-operation, when these complications are detected later on after patients discharge from operating theatre.

Post-operative data;

Smooth postoperative course occurred to all patients even for the patients with pre-operative heart failure, impaired hepatic and renal functions. All patients were extubated within few hours post-operative. Similar experience was reported by ***Ji et al. (2020)*** only prolonged ventilation (≥72 hours) occurred in 4 (2.2%) patients.

Post-operative ECG: The patients in our group who were in AF, RBBB. LBBB pre-operatively remained in AF,RBBB,LBBB post-operatively, with no other new patients with post-operative AF.

Ji et al. (2020) reported new-onset atrial fibrillation in 5 (2.7%) patients all the 5 patients returned to sinus rhythm following electrical cardioversion.

In our study, although we have mentioned LBBB as a complication of myectomy occurring in (55%) of our patients, ***Ji et al. (2020)*** reported LBBB in (41.5%) of patients. Cui et al., recorded LBBB in (38.8%) concluded that LBBB is a common sequela after septal myectomy but does not influence post-operative mortality.

In our study, The 2 patients (5%) who were on temporary pacemaker post-bypass, remained in **complete heart block** post-operatively and both required implantation of permanent pacemaker before discharge actually. The pre-operative RBBB, as we have mentioned before, the risk of post-operative CHB increases markedly with pre-operative RBBB.

Cui et al reported (1.1%) developed right bundle branch block (RBBB), and 0.6% had complete heart block (CHB) after myectomy in patients with preoperative normal conduction, Among 112 patients with baseline RBBB, (34.8%) developed CHB post-operatively. Overall, only 2.3% of their patients developed CHB.

Ji et al. (2020) reported CHB in 6 (3.3%) patients in their study half of them had preoperative RBBB, all required permanent pacemaker implantation

Talukder et al. (2020) reported 1(4.3%) patient required a permanent pacemaker for complete heart block.

Schleihauf et al. (2018) reported LBBB in (22%) of patients and RBBB in 9% of patients in their study which included 23 patients.

Pruna-Guillen et al. (2021) reported ONE (1.9%) patient with New CHB (PPM implantation during hospital stay. (61.5%) of patients developed LBBB after Septal myectomy.in their study that included 52 patients.

While Bonde and colleagues in their review of multiple myectomy studies reported that up to 10% required PPM for CHB. From all the presented data, it can be concluded that the 7.5% in our study, although a little high but still lies within the accepted range.

Immediate post-operative (pre-discharge) assessment:

Clinical Assessment: all patients reported early considerable improvement.

Post-operative pre-discharge echocardiography, our study showed that the immediate follow-up PG ranged from 2–40 mmHg with a mean of (14.27±8.32).mmHg.

The immediate post-operative mean of (14.27±8.32). mmHg was significantly lower than preoperatively (P-value<0.001). ***Talukder et al. (2020)*** reported a similar immediate post-operative mean PG (18.95 ± 7.9 mmHg) from (81.57 ± 17.05) preoperatively which was statistically significant (*P* <.001).

Rastegar et al. (2017) reported resting LV outflow gradients were reduced from (56±42) mmHg preoperatively to (0.6±5.4) postoperative which was statistically significant (*P* ≤.001).

Wang et al reported that immediate predischarge LVOT PG decreased to 11 mm Hg (8-15 mm Hg) from 78 mm Hg (61-100 mm Hg) preoperatively.

Mitral *incompetence*: our patients showed marked reduction in the degree of MR post-operatively with (97.5%) had no or mild mitral regurgitation **(P value <0.001).** Also what they reported. In our study moderate MR was detected in 1 patient (3%), but this patient had pre-operative severe MR.

Talukder et al. (2020) reported (8/23) patients (34.7%) with preoperative moderate mitral regurgitation mean (3.14 ± 0.73) needed no intervention and had no or mild mitral regurgitation postoperatively (0.95 ± 0.50) with (p-value <.001) which is statistically significant.

Rastegar et al. (2017) reported In the 31 patients with preoperative severe mitral regurgitation (3 or 4+), postoperatively (87%) had no or mild mitral regurgitation and four (13%) had residual moderate mitral regurgitation, including 22 (71%) who required insertion of a mitral valve annular ring and 1 (3%) with mitral valve replacement.

Ji et al achieved significant improvements in the severity of MR following myectomy with mean 1.0 (0-1.0) in both groups (*p-value* < 0.001) ***(Ji et al., 2020). Schleihauf et al. (2018)*** reported (38%) had moderate to severe MR with no change in infants < 1 year old (50% mr pre -50% mr post) and significant change in the children group(1-18 years old) (80% mr pre-22% mr post).

SAM*:* in our study,residual mild SAM was detected in 3(7.5%) of patients.

Talukder et al. (2020) also reported that preoperative SAM (82.6%) (16/23) patients had grade IV SAM, and (3/23) patients had grade III SAM (3.67 ± 0.66) markedly decreased In immediate postoperative Cardiac Echo as 2 (8.7%) patients only had grade I SAM (0.10 ± 0.30).

Wang et al reported preoperative SAM (100%) was eliminated in almost all patients, except for 2 with persistent mild SAM (2/275)(0.7%).

Ji et al. (2020) reported preoperative SAM (100%) was eliminated following myectomy except in 17 patients, with a lower incidence in the combined group (0 vs. 13.0%, *p* - 0.007).

Schleihauf et al. (2018) reported Pre-operative SAM in (80%) of patients from (1-18) years old was totally eliminated while Pre-operative SAM (67%) in infants less than one year old become (33%) (p-value= 0.1).

Mortality no patient died in hospital stay period.

As regards morbidity, in our study one female patient (3%) developed CHB 7 months after operation and needed PPM to be implanted. ***Lisboa et al*** also reported similar results with one patient (3%) developed CHB in the first post-operative year.

Clinical assessment:

All patients show significant improvement in clinical assessment as dyspnea FC III, IV disappeared, (95% free of symptoms), we had only 2.5% of patients with mild symptoms (FC I),1 patients (2.5%) with moderate symptoms FC II (they were in FC IV preoperative which mean significant symptomatic improvement). All 39 patients were free from syncope, palpitations and angina.

We agree with ***Talukder et al. (2020)*** who reported during follow-up, all patients reached NYHA class I, which was statistically significant ($P \leq .001$).

Our results is better than ***Ji et al. (2020)*** reported that 173 patients followed up in a period 10 (6–15) months NYHA functional class significantly decreased from the preoperative value in both groups, with no patients being class III or IV, FC I (75%), FC II (25%).

Short term Echocardiographic assessment

Our mean PG (17.37±7.81). mmhg which is higher than what recorded by ***Talukder et al. (2020)*** reported mean PG (8.87 ± 2.54)mmhg but still results remain very satisfactory, and showed no statistical difference when compared to immediate post-operative readings

In our study SWT mean (1.44±0.36) cm which is much lower than what reported by ***Talukder et al. (2020)*** SWT (15.02 ± 1.94)mm.

Our short term result is the same value as immediate post-operative echo ***(Talukder et al., 2020)***

Echo shows, no Mitral regurgitation (47.5%),mild degree grade **I** (47.5%)

Moderate MR grade **II** (5%) This shows that Mitral regurgitation is usually eliminated without the need for additional mitral valve surgery.

We agree with ***Talukder et al. (2020)*** who reported that MR improved from mean (3.14 ± 0.73) preoperatively to (0.76 ± 0.44) at short term follow up both studies our and their shows significant statistical difference when comparing the pre-operative with short-term follow-up degree of MR. And also both reported no significant statistical difference between short-term mean MR and immediate post-operative.

There was an increase in the percentage of patients with SAM from 7.5% on immediate post-operative to 32.5% on short-term, but we think that this increase is clinically insignificant as all of them had mild SAM with no effect on LVOT gradient or degree of MR.

Follow up of AR showed no increase in severity in the 1 reported patient with mild AR on immediate follow-up, with one newly-developed mild AR.

Mid-term follow-up:

This period extended from 1 to 5 years following 40 patients after operation.

Mid term mortality & morbidity:

In our study(No) patients died in this follow up period.

Rastegar et al. (2017) reported Late deaths occurred in 11/482 (2.28%) patients at 59±15 years of age, (3.5±1.7) years after myectomy. Three of the deaths were due to HCM-related causes: two patients who developed end-stage heart failure and systolic dysfunction (who were not candidates for heart transplant), and one patient with sudden death but without conventional risk factors. The eight other deaths were due to non-cardiac etiologies: three with multiple co-morbidities, one from cancer, one from illicit drug use, and one from mesenteric ischemia. Cause of death in two patients is unknown.

Wang et al reported (1%) deaths at the latest follow-up (14 months [7-24]) Two male patients aged 15 and 14 years died of suspected sudden cardiac arrest 15 and 16 months after the operation, respectively. The former had syncope (once) and SWT of 36 mm preoperatively, and the latter had SWT of 31 mm and terminated the use of B -blocker medication after the operation without consulting a physician. Both patient underwent isolated myectomy and denied a family history of HCM and SCD. A 66-year-old male patient died of lung cancer 16 months after the operation. All 3 patients had LVOT PG less than 15 mm Hg at the latest TTE examination and were categorized in (NYHA) class I when they died. The cumulative survival probability was 99.28% at1 year and 96.98% at 5 years.

Pruna-Guillen et al. (2021) reported (3.8%) deaths at follow up period as, An 81-year-old patient died 3 years after the operation as a consequence of esophageal adenocarcinoma and an 87-year-old female died 5 years after the procedure as a consequence of progressive renal failure managed with comfort measures.

Clinical assessment showed sustained symptomatic improvement among the majority of our patients. As only 12.5% were in mild dyspnea and 87.5% free. we agree with ***Rastegar et al. (2017)*** as they reported (64%) were asymptomatic in NYHA class I, 113 (29%) were in class II with mild symptoms, and 25 (7%) had persistent limiting class III-IV symptoms.

Echocardiographic assessment

Our results showed Mean PG (18.1±9.53). ***Rastegar et al. (2017)*** reported at follow up period mean (3.2±2.8) years PG (1.2±6.8) mmhg despite it is much lower than our result we both agree in concluding that reduction in LVOTO continues over mid-term follow up.

Echo shows, no Mitral regurgitation (52.5%),mild degree grade I (42.5%)

Moderate MR (5%) the same as short term. this shows improvement as 2 patients with mild MR becomes free.

Also 75% of our patients showed no SAM, but 10 patients (25%) had mild SAM (was 32.5% at short term) this is much higher than what reported by ***Ji et al. (2020)*** who found SAM in(6%) 11 patients at the 3 years follow-up, of whom 3 were diagnosed with moderate MR and the remaining 8 were diagnosed with mild or less MR. There were no cases of severe MR at follow-up. Comparatively, patients in the combined group had a lower incidence of the SAM syndrome (0 vs. 8.8%, p =0.034) despite no significant difference in the incidence of moderate residual MR (0 vs. 2.4%, p = 0.279). None had MV flail or prolapse at the most recent evaluation.

Regarding AR we noticed only 12.5% with mild degree of AR we agree with ***Ji et al. (2020).***

Long-term follow-up assessment

One patient (2.5%) died suddenly 7 years after surgery, one patient (2.5%) died 21 year after surgery, another one (2.5%) died 13 year after surgery finally one patient (2.5%) died 9 years after surgery among our 11 patients at mean time (3.67±5.2) years ranges from 1-21 years.

AS ***Schleihauf et al. (2018)*** who reported Long-term follow-up data on 19 patients at a mean time of (8.9 ± 8.2) years after myectomy were obtained in 19 patients. Two patients (9%) died during long-term follow-up: 1 patient in Group A with unknown underlying genetic aetiology and additional ventricular pre-excitation died of SCD 2.1 years after first myectomy (1.1 year after redo myectomy); 1patient in Group B died of intractable CHF and CHB 18.4 years after surgery while waiting for heart transplantation

Other studies reported on long-term mortality 10% this may be due to small number of our patients.

As regards morbidity (other than need for re-myectomy), in our study there was no morbidity on long term follow-up. Morbidities reported by other studies on long-term included CHB that required a permanent pacemaker (200,201), ICD implantation for patients at risk of SCD**,** ischemic cerebro-vascular event (201), CHF requiring hospitalization and cardiac transplantation. ***(Schleihauf et al., 2018)***

As regards need for re-myectomy, in our study none of the patients required re-operation for residual gradient or residual MR. Some studies reported the same results(200,201), While other studies reported that few of their patients needed repeat myectomy (range 0.3- 4.7%)(194). Also, ***Schleihauf et al. (2018)*** two patients 9% in Group A required reoperation at 0.9 and 6.5 years after operation, respectively, because of persistent or increasing LVOT obstruction, both showing ventricular pre-excitation. There was no death related to reoperation.

Clinical assessment: in our study, sustained symptomatic improvement was also observed on long term, with many other studies reporting similar finding ***(Woo et al., 2005).***

Significant reduction in mean dyspnea FC on long- term was noticed in our study as well as other studies with all reporting significant statistical difference when comparing the long-term with pre-operative reading (P value <0.05) no symptoms in (72.7%),NYHA Class I (27.3%).

Schleihauf et al most patients were in clinically improved condition on long-term follow-up: they were classified in NYHA/ Ross functional Class I (16%)or II(58%)and 2 patients (10%)in class III–IV ***(Schleihauf et al., 2018).***

Echocardiographic data also showed sustained improvement among all our patients with none of our patients with significant residual LVOT gradient. Mean long term LVOT PG (17.55±11.13).

Schleihauf et al. (2018) there was a long-lasting reduction of the LVOT gradient in both groups 6 [0 to 115]mmhg.

Mitral incompetence &SAM: in our study, improvement was also sustained with only 4 patients with mild regurge 36.5% this is overestimated percentage due to small patients number, with none of our patients with more than mild MR.

Schleihauf et al. (2018) both groups, about one-third of patients had persistent systolic anterior motion of the mitral valve associated with (37%) moderate mitral valve regurgitation in the long term. in our study, only 1 patient (10 %) had SAM on long-term and it was mild in degree, indicting marked improvement as compared to the fact that all 10 patients had SAM pre-operatively.

AR In our study only 3 patients with mild AR (27.3%) on long term follow up ***Schleihauf et al. (2018)*** reported that 2 patients (16%) demonstrated new moderate aortic valve regurgitation on late follow-up, not requiring intervention. Both developed over time and were not already present at early postoperative follow-up.

Follow-up:

The mean follow up was (3.67±5.2) years ranged from (1-21 years). The follow up was 100% complete ***(Table 12)***

Overall survival

In our study among 40 patients, 11 can be followed up, the overall all-cause mortalities were 4 patients (10%) died 7 &9&13&21 years after operation giving survival of 90% of patients after 21 years of follow up.

While ***Rastegar et al. (2017)*** reported Overall long-term survival after myectomy was 98% at 1 year, 94% at 5 years and 91% at 10 years, and did not differ from the age- and gender-matched general U.S. population (log-rank P=0.9).HCM-related mortality after myectomy was 98% at one year 97% at 5 years and 97% at 10 years, and was significantly higher than the age- and gender-matched general U.S. population, most of other reports have better long term survival at 10 years may be due to bigger number of patients in their series or presence of hepatic and renal

Comorbidities causing death in 2 out of our 3 mortalities. HOCM related death occurred only in one patient in our series making survival free from HCM-related mortality in our study of 100%, and 75% at 5 and 10 years, respectively.

6. CONCLUSION

We concluded that Extended myectomy is sufficient and efficient in treatment of HOCM and associated SAM &mitral regurgitation with preservation of mitral valve keeping replacement only for patients with intrinsic mitral valve abnormalities

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