

Technical Report

To Medical and Allied Professions

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Series Editor
Professor Harvey White



May 2003

Report No. 81

Balloon Mitral Valvotomy

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Introduction

Balloon mitral valvotomy (BMV) is the preferred method of intervention in patients with symptomatic mitral stenosis, and has been widely adopted. Patients who are suitable for this procedure can expect immediate haemodynamic and symptomatic improvement, lower risks of emboli and atrial fibrillation, and continuing relief for periods equivalent to those obtained with open surgical valvotomy, but without the associated morbidity and cost.

The procedure

Dr Kanji Inoue first performed BMV in 1982 using an ingeniously designed catheter.¹ A number of alternative percutaneous procedures were then tried with traditional cylindrical balloons, and a range of techniques (some quite elaborate) were utilised to stabilise the somewhat cumbersome balloons across the mitral valve during inflation. However, the commercially modified Inoue balloon (Toray Medical Company Ltd, Tokyo) quickly became the most popular choice for BMV because of its relative ease of use and lesser potential for procedural complications. Comparative studies between both methods have reported similar results, but with longer procedural and fluoroscopy times for the (double) cylindrical balloons.² More recently, a metallic valve dilator, rather similar to the original Tubb's dilator for closed valvotomy performed via a thoracotomy, has been developed for percutaneous use in order to allow resterilisation and reuse of the equipment, thereby reducing the cost of the procedure.³ This is an important consideration in some less affluent countries where rheumatic heart disease is endemic. It is difficult to resterilise the Inoue balloon, although this has not necessarily prevented its reuse in some centres with severely limited resources and large populations to treat. The Ministry of Health's reimbursement for each BMV at Green Lane Hospital is approximately one fifth of the amount received for a routine valve operation, but does not fully cover the actual cost.

The Inoue balloon set comes with specially designed equipment to facilitate the passage of the 12-French balloon catheter from the femoral vein through the atrial septum and across the mitral valve. Different balloon sizes are available and are usually chosen according to the patient's height and the morphological appearance of the valve at echocardiography. A well-sited transseptal needle puncture of the bulging atrial septum is one of the critical steps of the procedure. The usual landmarks for septal puncture are often not present, and special care is required to avoid puncture of other structures (leading to tamponade), and to position the puncture site so as to facilitate the subsequent passage of the balloon towards and across the valve. The balloon is inflated in measurable stepwise increments to its designated maximum diameter (which can be slightly exceeded if necessary) or until a satisfactory result is obtained (Figure 1). Some judgement is required at this point in order to determine when the best possible result has been obtained and when further dilatations might result in damage to the valve. The inflation/deflation sequence is rapid, unlike that experienced with cylindrical balloons. The shape of the balloon during the inflation sequence assists in maintaining a stable position across the valve. Simultaneous left atrial and left ventricular pressures are recorded between each inflation. Colour flow Doppler echocardiography is performed to help determine the adequacy of the result and the degree (if any) of mitral regurgitation produced, and left ventricular angiography can be undertaken if required. One or both commissures are split, the former often still providing an adequate result.

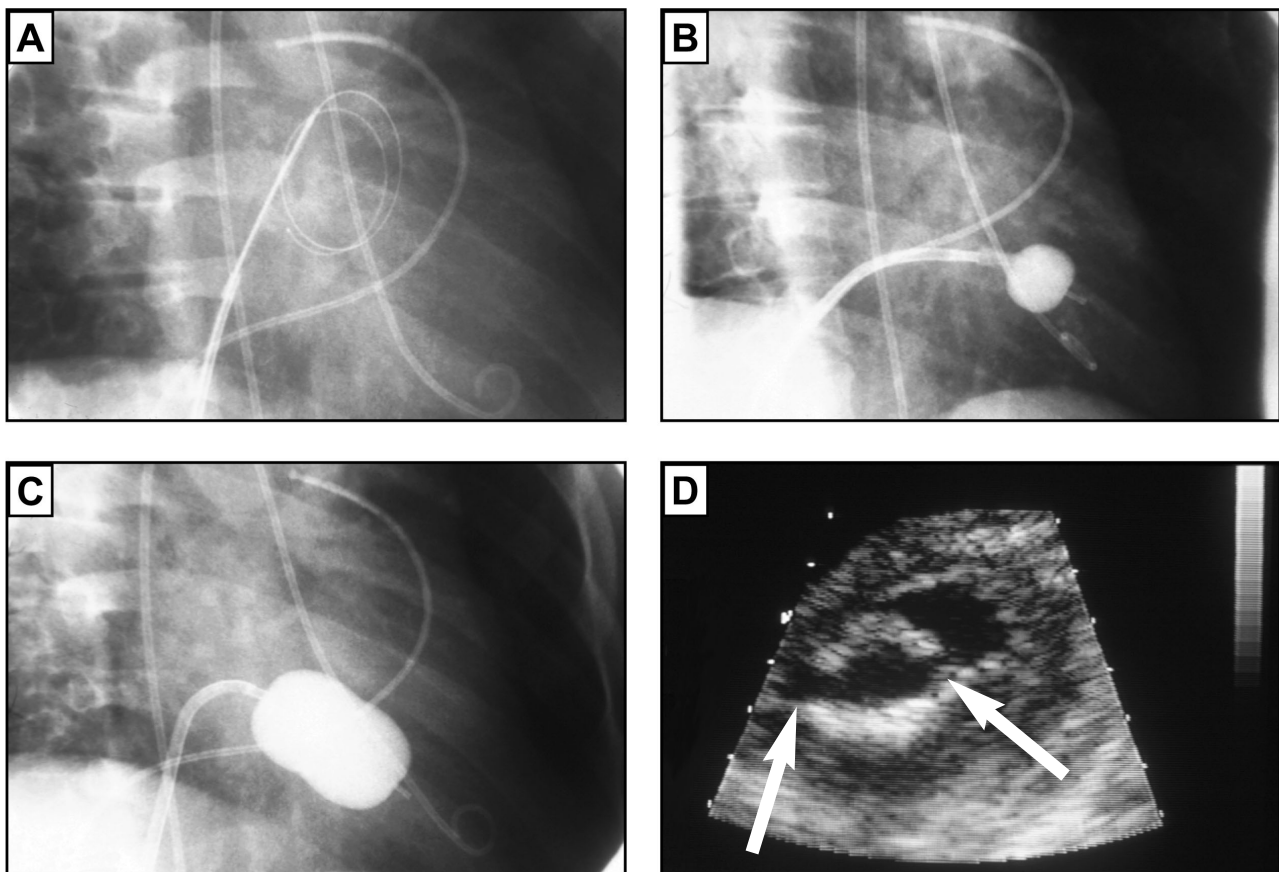


Figure 1: Right anterior oblique angiographic views showing (A) the stretched Inoue balloon catheter, which has been advanced transseptally over the Inoue guide wire into the left atrium, (B) across the mitral valve with partial inflation of the distal half of the balloon below the valve, and (C) fully inflated across the mitral valve. A Swan-Ganz catheter and pigtail catheter have been placed in the pulmonary artery and left ventricle respectively. (D) Short-axis echocardiographic view showing separation of both commissures (arrowed) of the thickened mitral valve.

In special circumstances the procedure is performed with the assistance of transoesophageal echocardiography with either sedation or a general anaesthetic. The advantages of this approach are that it helps guide the transseptal puncture where there is difficulty and allows the degree of resulting mitral regurgitation to be measured with greater accuracy than might be obtained in some patients with transthoracic echocardiography, but a general anaesthetic offsets one of the benefits of a percutaneous procedure. The technical details of the BMV procedure are beyond the scope of this report, but a number of references are available.

Complications

Three major potential complications are pericardial tamponade (usually related to the transseptal procedure), important mitral regurgitation due to damage to the valve or chordae during balloon inflations, and embolic events. Should pericardial tamponade suddenly develop, the BMV procedure can still be successfully completed once a pericardial drain has been promptly inserted. Since the balloon is robust and no wires enter the left ventricle, balloon rupture and left ventricular wall perforation do not occur. Systemic emboli can be largely avoided by screening for left atrial thrombus on transoesophageal echocardiography shortly before BMV and administering heparin once the atrial septum has been crossed. There is a significant learning curve in the technical procedure and refinements, and there is less risk of complications as the operator's experience grows.⁴

While BMV may be performed as an outpatient procedure in selected cases, it is the custom at Green Lane Hospital to admit patients one day before BMV and to discharge them one day afterwards. Warfarin is withdrawn, and heparin is used to bridge the interval before BMV if there is a significant risk of embolism. Transoesophageal echocardiography is performed mainly to exclude atrial thrombus, but also to inspect the subvalvular structures (which may be difficult to visualise well from transthoracic windows) and to confirm the leaflet and atrial septal appearances and the degree of mitral regurgitation. Transthoracic echocardiography is performed one day before and after BMV, and is also available for use during the procedure.

Selection of patients

The severity of symptoms in patients with mitral stenosis does not always reflect the degree of stenosis. Some patients are relatively intolerant of mild stenosis (mitral valve area $>1.5 \text{ cm}^2$), while others with apparently modest symptoms may have a severely stenosed valve (mitral valve area $<1.0 \text{ cm}^2$) and a high mitral valve gradient. With the possible exception of three-dimensional echocardiography or the surgeon's examining finger, invasive and noninvasive measurements of the mitral valve area are not always reliable.^{5,6} An objective assessment of effort tolerance and haemodynamic changes during exercise may be appropriate in some cases. The presence of low cardiac output due to a combination of significant pulmonary hypertension, atrial fibrillation and a large left atrium may result in a low mitral valve gradient despite severe valve narrowing. BMV is indicated in symptomatic patients with moderate or severe mitral stenosis, but may also be desirable in those with significant symptoms despite apparently milder degrees of stenosis or, conversely, those with milder fatigue or breathlessness in the presence of important mitral stenosis, pulmonary hypertension and favourable valve morphology. When sinus rhythm is preserved, one might reasonably hope that a successful valvotomy would delay the onset of atrial fibrillation and reduce the medium-term risk of systemic embolism and development of pulmonary vascular disease with right ventricular dilatation and tricuspid regurgitation. Positive left atrial remodelling after BMV, with a reduction in vulnerability to atrial fibrillation, has been demonstrated after successful BMV, and might further reduce the threshold for performing this intervention.⁷ Spontaneous echocardiographic contrast in the left atrium (a sign of low flow and a precursor of left atrial thrombus formation) tends to disappear on transoesophageal echocardiography after BMV, with a demonstrable reduction in left atrial hypercoagulability and a reduced risk of subsequent embolic events.⁸⁻¹⁰

BMV may also be indicated before or during pregnancy, during which mitral stenosis is often poorly tolerated due to expansion of plasma volume and sinus tachycardia with reduced left ventricular diastolic filling times. This special situation requires careful management and collaboration with obstetric colleagues. While beta-blockade, diuretics and bed rest are helpful, BMV allows less troublesome antenatal care, a reduced hospital stay and a safer delivery. The risks to the fetus from cardiopulmonary bypass (if surgery were to be performed) are avoided, and scattered radiation exposure can be minimised by short fluoroscopy times and lead abdominal and pelvic screening. However, BMV in this setting does appear to carry a greater risk of maternal complications.

In general, therefore, there is a lower threshold for recommending BMV than would be the case for surgical (open) valvotomy.

On auscultation, a crisp opening snap implies a pliable valve suitable for valvotomy. The diastolic murmur may be highly variable in amplitude and duration, depending on the transmitral flow, and an abbreviated murmur does not always imply a milder degree of valve narrowing. With experience, the duration of the S2-OS interval is a useful sign in assessing severity at the bedside. A murmur of mitral regurgitation is a cautionary finding since it is not uncommon for mitral regurgitation to mildly worsen after BMV, although it can also improve. However, mild mitral regurgitation is not a contraindication against BMV. The Wilkins score has been widely adopted for the assessment of valve morphology on transthoracic echocardiography and to determine the suitability of the procedure and to predict the outcome.¹¹ The mitral valve is examined for leaflet thickness, mobility, the location and extent of any calcification, and chordal fusion and shortening. Each of these factors is given a score (near normal = 1, severely affected = 4), with a maximum possible score of 16. A total score of <9 is generally considered suitable for BMV, and a score of 9-10 is borderline (but often accepted). However, the scoring system is rather subjective, and one can incorrectly estimate the presence of calcification and degree of chordal involvement, especially if the echocardiographic views are limited. The presence of calcification or dense echoes in the region of the commissures in short-axis views may preclude effective BMV or risk tearing of the valve leaflet.¹² Significant deformity of the distal balloon contour during inflation suggests that the extent of subvalvular disease has been underestimated on transthoracic echocardiography, and should alert the operator to take particular care, perhaps by exchanging the balloon for a smaller one. Severe subvalvular involvement with the papillary muscles adjacent or adherent to the valve itself is a contraindication against BMV. Similarly, the presence of left atrial thrombus is a contraindication against BMV, although some operators will proceed with caution if the thrombus is within the atrial appendage and appears relatively small and well organised. Left atrial thrombus may disappear after 4-6 weeks of low-molecular-weight heparin therapy, allowing BMV to be rescheduled. Mitral restenosis after surgical valvotomy or BMV can be successfully ballooned if commissural refusion is the cause, rather than a progressive increase in valve thickening or calcification with chordal tethering. If clinically important tricuspid regurgitation is present, mitral valve surgery (including tricuspid annuloplasty) should be considered instead, but reduction of tricuspid regurgitation has been observed where pulmonary hypertension has been relieved with BMV and where tricuspid annular dilatation is not excessive. However, the literature is not unanimous on this matter.^{13,14} The presence of mild or moderate aortic valve disease is not a contraindication against BMV.

Results

Compared with open or closed surgical valvotomy, randomised trials in patients with favourable valves have shown comparable, if not better, results with BMV in the immediate and medium to long term (up to seven years), with similar complications in terms of mortality, stroke and severe mitral regurgitation.^{15,16} At Green Lane Hospital, over 200 patients with ages ranging from 13 to 73 years have undergone BMV, including 25 where the procedure was performed during pregnancy and 14 who had undergone previous surgical valvotomy between 5 and 33 years earlier. There have been no deaths and no fetal losses. A third of the patients were in atrial fibrillation, 12% had mild mitral valve calcification on fluoroscopy, and nearly 10% had severe pulmonary hypertension with mean pulmonary artery pressures of >50 mmHg. Urgent mitral

valve surgery was required in 4% of patients, mostly during the first two years following the introduction of the procedure. A final planimetered valve area of $>1.5 \text{ cm}^2$ on echocardiography was achieved in 96% of the remaining patients. Post-BMV, the mitral valve mean gradient was 5 mmHg, and the final valve area was 1.9 cm^2 (Gorlin) and 2.1 cm^2 (planimetered) (Figure 2). These results are similar to those reported previously.¹⁷ A small increase in mitral regurgitation may be seen. The small defect in the atrial septum usually heals within six months, but may occasionally persist with minor shunting.^{18,19} Patients often notice an immediate symptomatic benefit and can usually be expected to resume normal activities shortly after discharge.

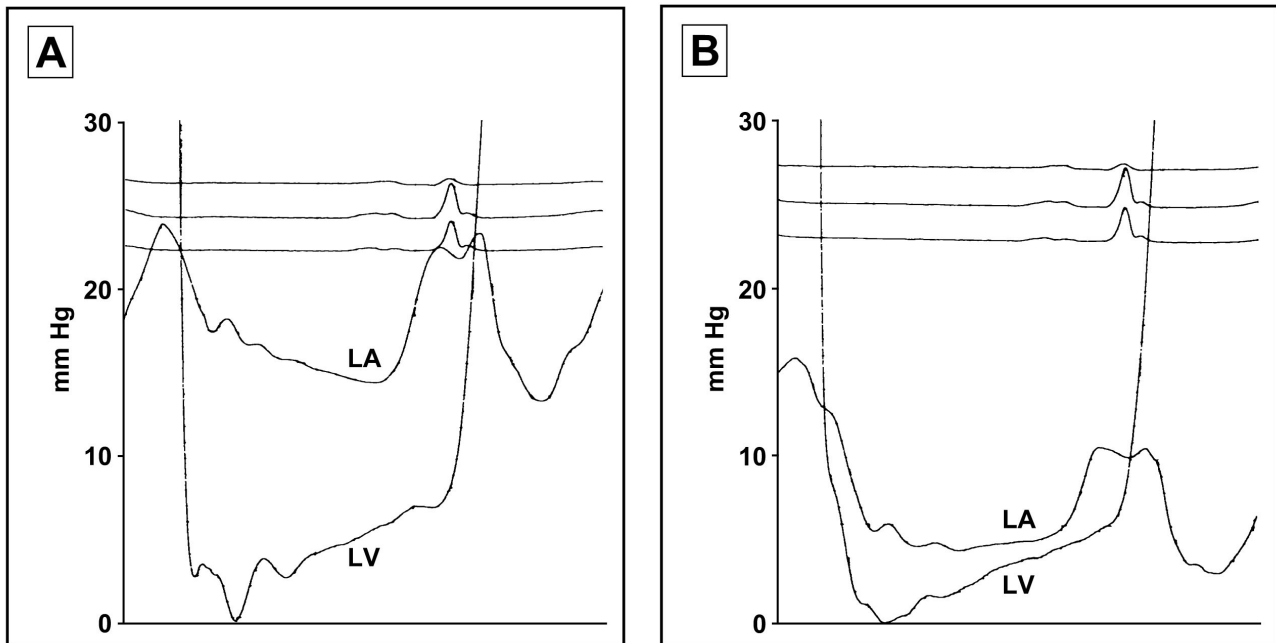


Figure 2: Left atrial (LA) and left ventricular (LV) pressures **(A)** before and **(B)** after balloon mitral valvotomy.

In a meta-analysis of two studies involving a total of 1,156 patients (mean age 48 years), Rahimtoola et al reported that $61 \pm 5\%$ of patients who had undergone BMV with a good initial result (mitral valve area $>1.5 \text{ cm}^2$ with no important mitral regurgitation) had 10-year freedom from death, mitral valve surgery, repeat BMV and New York Heart Association (NYHA) class III-IV symptoms.²⁰ Of those who had an early mitral valve area of $>1.5 \text{ cm}^2$ and a mean left atrial pressure of $<18 \text{ mmHg}$, only 10% needed mitral valve surgery or repeat BMV within seven years. Palacios et al followed-up an older group of 879 patients (mean age 55 years) for 12 years after BMV, and reported event-free survival rates of 41% in those with a good initial result and an echocardiographic score of <8 , versus 23% in those with an echocardiographic score of >8 .²¹ Chen et al found that 8% of 202 patients (mean age 38 years) experienced mitral restenosis over a mean follow-up period of eight years after BMV.²² The factors that have been shown to adversely affect the long-term outcome are an echocardiographic score of >8 , prior NYHA class IV symptoms and low cardiac output, an initially suboptimal mitral valve area and gradient after BMV, and the presence of important mitral regurgitation.²³ At present there is no proven strategy to reduce the incidence of restenosis in the longer term.

Follow-up results are not yet available for patients who have undergone BMV at Green Lane Hospital. Maintenance of penicillin prophylaxis is important for those at risk of recurrent attacks of acute rheumatic fever.

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*This report has been prepared at the request of the Editor of the Technical Report Series.
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