Video-assisted minimally invasive mitral surgery

- Equipment and material used

- Description of a simplified technique

- Presentation of initial results

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OVERVIEW OF THE PROCEDURE +

Equipment and material used

INSTALLATION

1) Induction of Anaesthesia: Cannulation of radial artery; standard, non-selective tracheal intubation; pillow under right side of the chest; draw line under breast and from femoral artery to groin; leave right jugular vein free as if for carotid surgery; set up Endoboy arm.

OPERATIVE PROCEDURES

2) Asepsis: Traction of breast by Ioban isolation drape

3) Introduction of extracorporeal circulation lines: Set-up and expelling air bubbles from venous tubing.

4) Right internal jugular vein puncture (Arrow puncture kit, double-lumen 20 cm 8 Fr. catheter, ref. CS-15802-E)

5) Heparinization 3mg/kg

6) Right groin access. Creation of 1 venal and 2 arterial purse string sutures with Gore-Tex CV 4.

7) Introduction of jugular cannula under extended trochanteric osteotomy. *DLP R cannula, "femorale arterial cannulae", no. 17 (ref. 57 417) except for low-weight patients - no. 14 (Ref. 57 414).*

8) Puncture of the femoral vein (DLP long no. 28, ref. 96428) set up under extended trochanteric osteotomy or for average and low-weight patients (ETHICON Cardiovation cannula size 25 – Fr, Ref. QD 25 or size 22 Fr – Ref. QD 22).

9) Introduction of femoral artery cannula (EOPA Arterial Cannulae 77418 or 77420)

10) Set up of lens at 30° + CO2 + camera with test of whites.

11) Thoracotomy: Introduction of a *10mm Thoracopore* for inserting the lens, with CO2 insufflation, regulating the flow from 2 to 2.6 L/min., then positioning of soft tissue clamp.

12) INITIAL extracorporeal circulation: Hypothermia to 32°.

13) Depression of diaphragm by *Ethibond 0/26* anchor on large patch, then opening of pericardium which is held by 2 *Ethibond 0/26* anchors. The 3 anchors are transparietal (*Endoclose Auto Suture Ref. 173022*), held by small forceps.

14) Dissection of superior and inferior vena cava.

15) Location of plegia (device) *single current DLP* 100 by 2 Prolene 3/0 patch anchors mounted on Tygon.

16) Aortic clamp: (Chitwood clamp) and induction of plegia.

17) Opening of left atrium and traction by *Ethibond 0/26*.

18) Mitral retractor introduced, then left ventrical aspiration.

19) Plasty: Long, standard instruments + special video instruments. *Peters 2/026* thread on the ring. Repair (*forceps, scissors, grips, Cardioxyl 5/0*)

20) SJM Tailor® Flexible Annuloplasty Ring. Sutures tied with *t/knot-pusher. (Heartport ref. KP1).*

21) Closure of left atrium. 2 Prolene 3/0.

22) Purging, unclamping, extracorporeal circulation weaning.

23) Medtronic electrodes.

24) 2 drains, 24 joints introduced by clamp and lens ports.

25) Decannulation: Jugular, femoral then arterial vein.

26) Protamine.

27) Analgesic infiltration of 4th intercostal space before parietal closure.

INTRODUCTION:

Over the past few years, there has been considerable progress in the field of mitral surgery, including better knowledge of functional anatomy, improvements in conservative surgical techniques, accurate surgical indications, and mastery of atrial fibrillation. The results of this surgery have been maximized, with post-operative mortality often less than 1% in the group undergoing accessible, surgical treatment of dystrophic mitral insufficiency. In such a context, the development of a new approach such as minimally invasive surgery is challenging; from an ethical point of view, it is virtually impossible to accept the morbidity normally associated with the learning curve. It was on this basis that we decided to adopt this new minimally invasive technique cautiously and progressively, trying to avoid any deterioration in the quality of the results compared to the standard sternotomy technique.

Aims:

1) Low-trauma intercostal access without intercostal retraction using the soft-tissue retractor (Fig. 10). This permits a short (< 6 cm) cutaneous incision, even though this is not a primary aim.
2) Absence of selective pulmonary intubation (Fig. 1)
3) Cannulation managed entirely by the surgeon, especially percutaneous jugular cannulation (Figs 5 and 6)
4) Reusable transthoracic aortic clamp (Chitwood clamp – Fig. 12)
5) Possible induction of cardioplegia if required (Fig. 13-15)
6) Optimal mitral exposure and visualization
7) Repair procedures using classic techniques

The technique we use is based largely on the original described by Hugo Vanermen. However, we have tried to simplify it and avoid using an Endoclamp, preferring instead the reusable transthoracic clamp designed by Chitwood but positioned differently from the standard position. This involves the introduction of a DLP device on the ascending aorta for the induction and reinduction of cardioplegia.
This technique does not change anything for the anaesthetic team. Rather, it makes it easier to use a new technique. In fact, there is no selective intubation, and jugular cannulation is controlled by the surgeon. Only the facts that the patient is lying in the lateral decubitus position on the operating table and that jugular access is left free are different from the installation for a sternotomy.

SURGICAL TECHNIQUE

▪ ***ADMISSION OF THE PATIENT***

- Clinical examination of the peripheral and, especially, the femoral pulse allows one to assess the likelihood of arteritis of the lower limbs. Echo/Doppler space evaluation is desirable if there is any doubt.

- History-taking and thoracic visualization should reveal the existence of any pleural adhesions or pulmonary emphysema contra-indicating access by right thoracotomy.

- Cardiac echocardiography in addition to classic mitral and ventricular function evaluation should identify any aortic insufficiency which could make anterograde cardioplegia risky.

- Coronary angiography should be carried out by puncturing the left groin in such a way that the right groin remains free of haematoma for surgical access. This applies especially where coronary angiography is carried out the day before surgery.

- Skin marking: It may be necessary the day before to use an indelible pen to mark the line under the breast in a female patient standing upright.

▪ ***PREPARING THE PATIENT***

The patient is placed in a supine position with a pillow under the right side of the chest; the right arm is bent slightly, with the palm facing the table – push under the right buttock. The elbow support point is protected by a soft foam cushion. A radial cannula is placed on the right; the central venous access points are arranged such that the right part of the neck is left free as if for carotid surgery associated with cardiac surgery.
Non-selective standard intubation is introduced. The transoesophageal echocardio-graphycatheter is introduced.
The line under the breast and right femoral artery are marked with a felt pen.
Asepsis can then be carried out, leaving 3 surgical access areas (right jugular + groin + 4th intercostal space).
Access for a sternotomy is left free in case a change of procedure becomes necessary.

Fig. 1: <u>Preparing the patient</u>

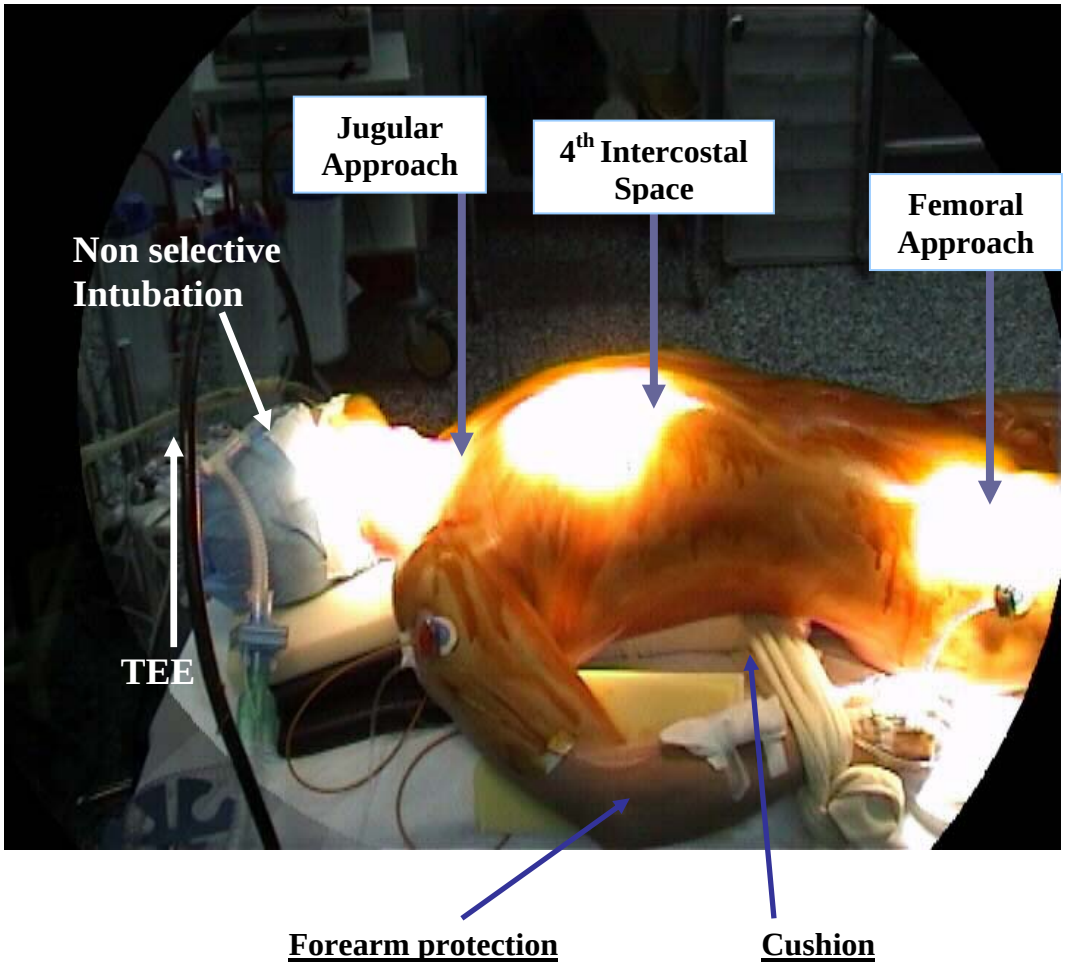


Fig. 2: <u>Video display screen</u>

This can receive echocardiography or camera images alternately, depending on the operating time.

Fig. 3: <u>Placing Ioban drapes over the area</u>
allows the skin to be retracted upwards to reveal the line under the breast in relation to the 4th intercostal space.

Fig. 4: <u>The installed video equipment</u>
The lens is mounted and attached to the Endoboy; it is a 5 mm diameter 30° lens. The whites test is carried out.

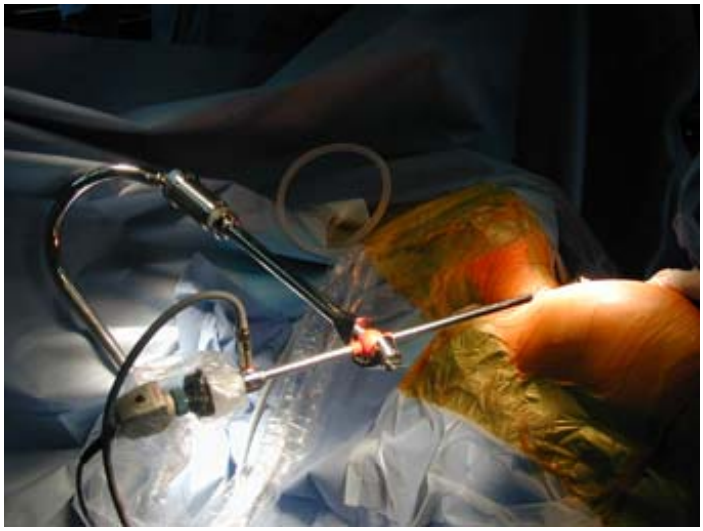
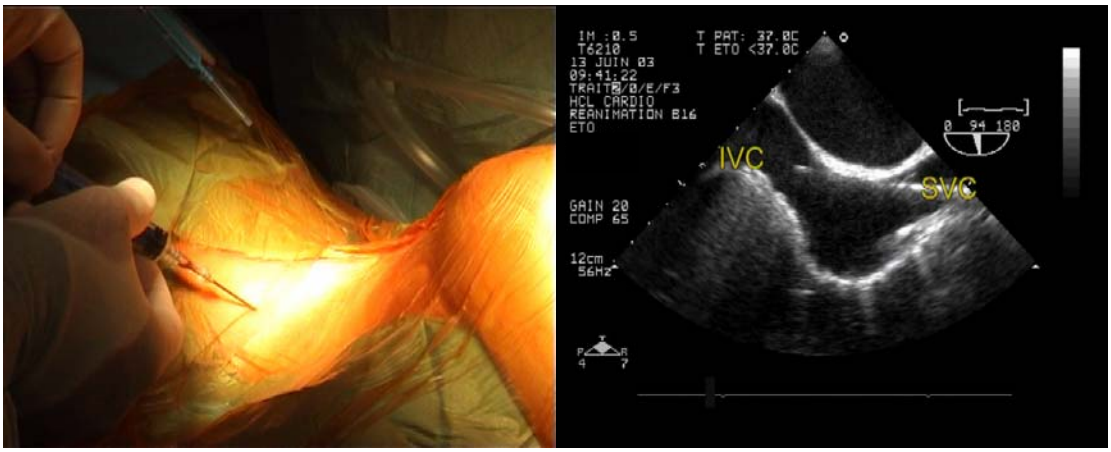


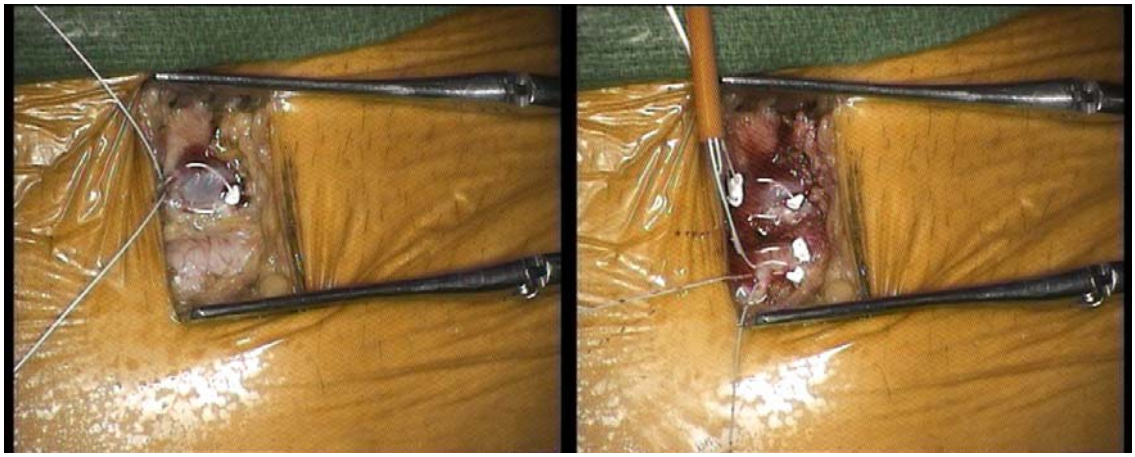
Fig. 5: <u>The right internal jugular vein is punctured</u> (Arrow puncture kit, double lumen, 1 cm, ref. S-15802-E).



If the carotid artery is punctured by mistake, it should be constricted briefly before resuming puncture of the jugular vein. Once the jugular vein has been punctured, the guidewire is introduced with echographic monitoring; this will allow verifying if the left atrium is reached. **Heparinization of 3 mg/kg can then be carried out safely** away from any puncture of the carotid artery. The jugular cannula is then inserted over the guidewire under echocardiographic control; generally, a DLP 17 French cannula is used (ref. 57-417) except for patients weighing less than 50 kg, where a 14 F cannula is adequate.

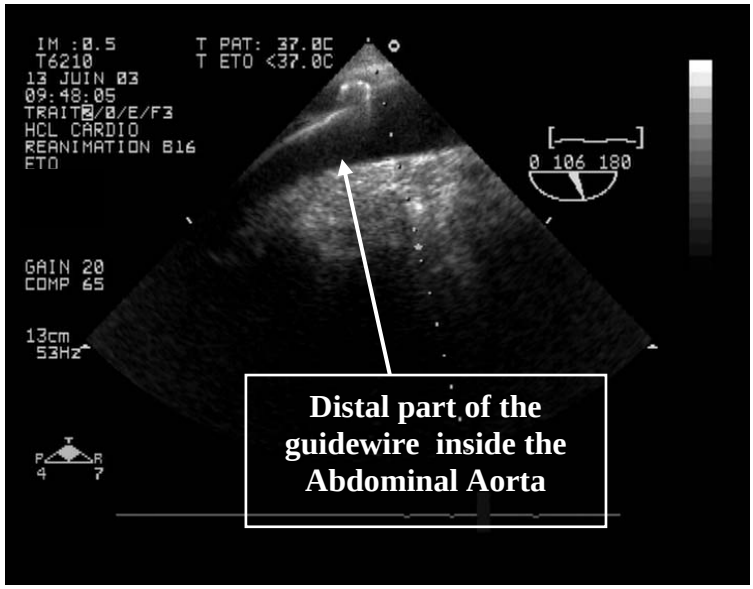
Fig. 6: <u>Introduction of the superior vena cava cannula under echographic control</u>

Fig. 7: <u>Groin access</u>
Only the anterior faces of the vessels are accessed with creation of a venous purse string using Gore-Tex CV4, then 2 U's of Gore-Tex CV4 on the femoral artery.



The femoral vein is punctured and a cannula inserted under extended trochanteric osteotomy control: DLP long 28 French or Heartport no. 25 or 23, depending on patient size. The femoral artery is punctured, then the arterial cannula is mounted over the guidewire. The Medtronic 18 French arterial cannula is used with women or patients of low weight (<70 kg), and the 20 French size with patients of larger body weight.

Fig. 8: <u>Extended trochanteric osteotomy</u> is used to verify (probe inserted as low as possible to show the descending thoracic aorta) that the femoral guidewire has been introduced correctly and pushed into the aortic lumen before introducing the arterial cannula. This maneuver aims at avoiding any risk of dissecting the aorta.



If the arterial injection pressures are too high at the start of extracorporeal circulation, the probe should be repositioned. If the arterial injection pressure does not normalize, you should not continue, but should convert to sternotomy for cannulation of the

ascending aorta. We experienced this situation on 2 occasions in patients with severe atheromatosis, but by taking this precaution, we have always avoided aortic dissection.
The thoracotomy is carried out mostly in the 4th intercostal space. Depending on the shape of the thorax and the silhouette of the heart on the thoracic image it is sometimes possible to access the 5th intercostal space, but given that our technique necessitates an approach from the ascending aorta for cardioplegia, choosing the 4th space is often preferable.

Fig. 9: <u>The lines in the extracorporeal circulation system</u>
These are arranged in such a way as to leave the right side of the thorax completely free.

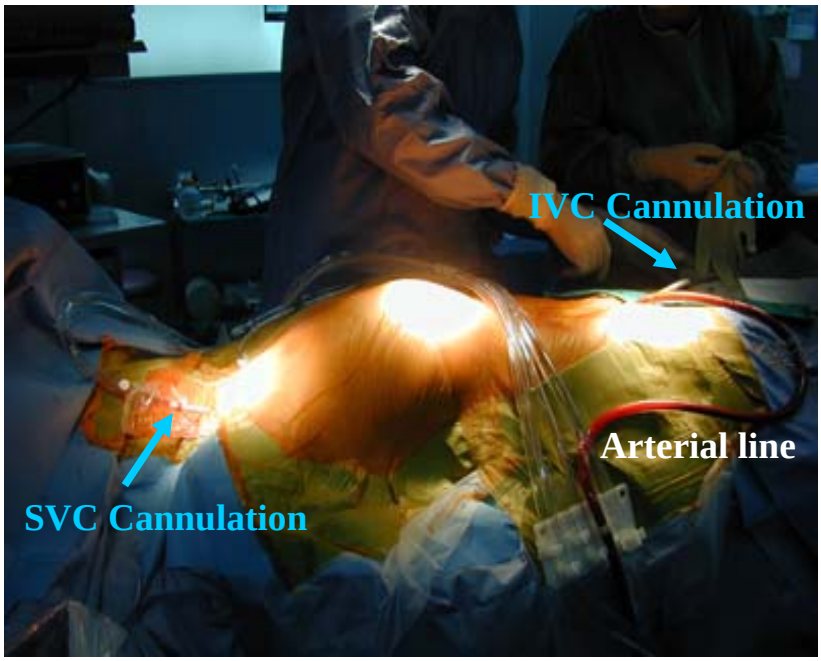
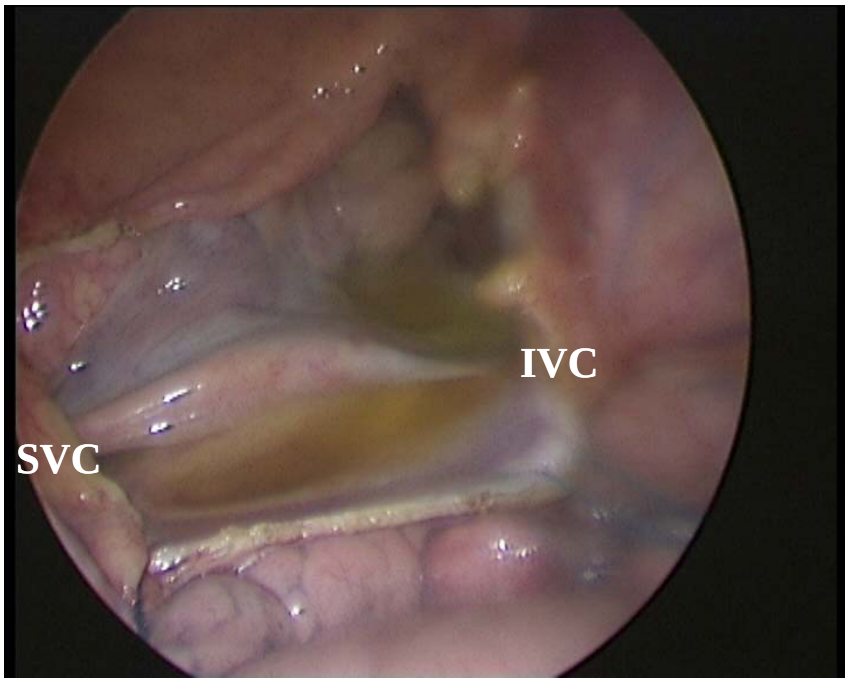


Fig. 10: <u>The $C0^2$ insufflation catheter</u>
It is introduced via the incision and held by the soft-tissue retractor.
A rigid retractor is not needed.

Start of extracorporeal circulation to induce moderate hypothermia of around 32°.

When the desired set flow rate is reached, ventilation is stopped, the intubation probe disconnected and the lungs collapsed.
It is sometimes necessary to put an Ethibond 0/26 on a patch over the dome of the diaphragm to flatten the diaphragm through a transparietal incision made using an Endoclose grip, ref. 17-3022.

Fig. 11: <u>Exposure of the pericardium</u>
Two Ethibond 0/26 sutures (arrows) are then placed on the lower side of the pericardiotomy to allow the heart to be pulled towards you.



The vena cava superior and the vena cava inferior are dissected free to allow opening of the left ventricle.

Fig. 12: <u>Introducing device</u>
A Prolene 3/0-120 on a patch and counter-patch is used to form a U-shaped purse string on the ascending aorta. A DLP single-current device then punctures the ascending aorta where it is held on the Ticron.

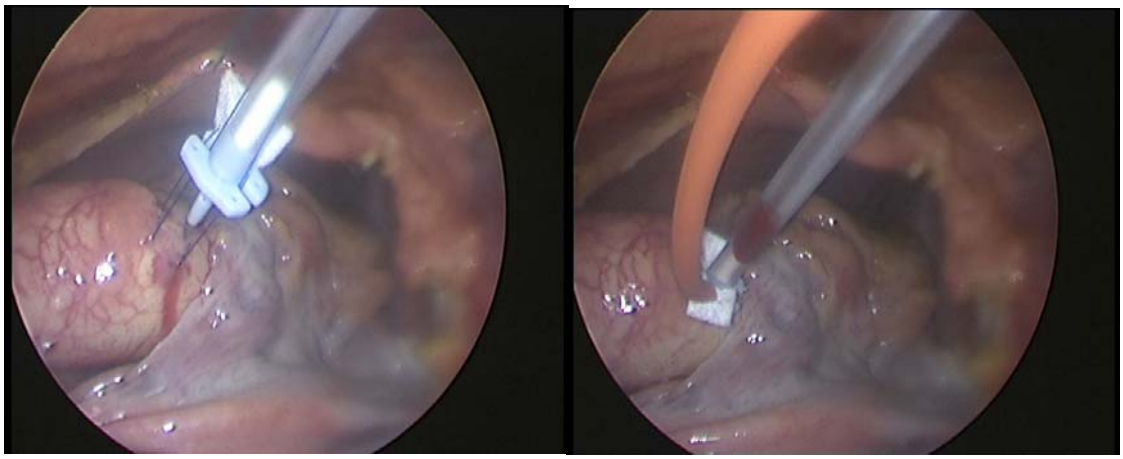


Fig. 13: <u>Aortic clamping</u>
The Chitwood trans-thoracic clamp is introduced into the 5th intercostal space along the medio-axillary line and directed down into the hollow transverse sinus. Thus, introduction of the clamp crosses the 5th space into a less traumatizing area away from the large pectoral muscle. The distal extremities of the 2 jaws of the clamp are closely monitored when it is introduced.

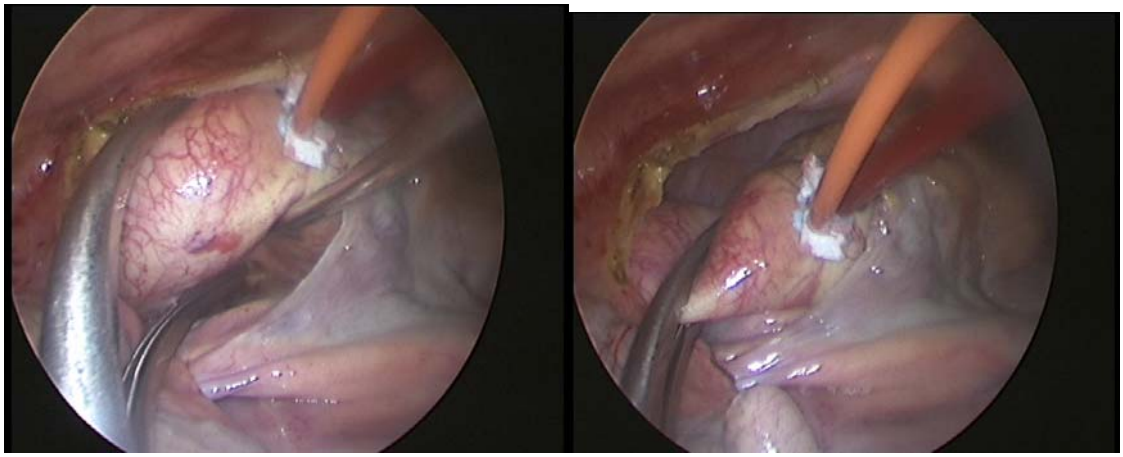


Fig. 14: <u>Opening the left ventricle</u> after induction of cardioplegia. An Ethibond 0/26 suture allows the upper side to be raised.

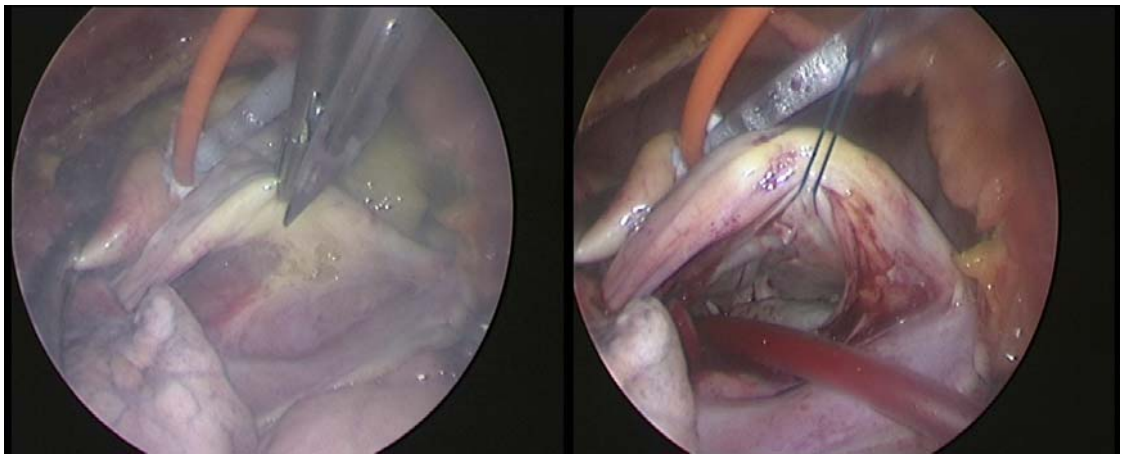
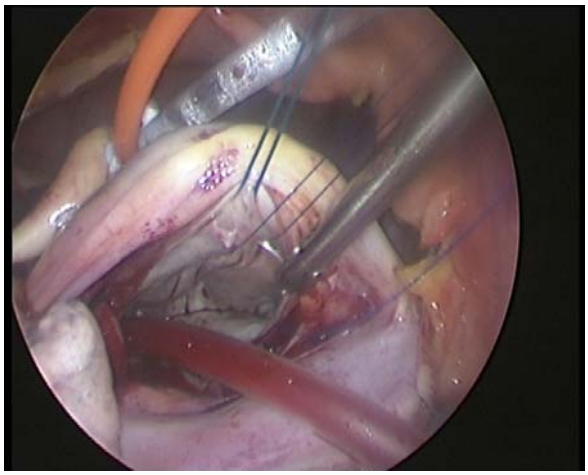


Fig. 15: <u>Patent Foramen Ovale</u>
Examination of the patent foramen ovale is then possible. And, if necessary, its closure is easily implemented by using a simple cross suture.



The mitral retractor is introduced, then the left ventricle aspiration is directed into the left lower pulmonary vein. Mitral exploration is then possible. The first sutures are introduced around the anterior commissures: 2 on the anterior lamina and 2 on the posterior lamina. These 4 sutures are then drawn up laterally using a transparietal steel thread.

Fig. 16: Mitral procedure
The modified surgical instruments are introduced between these two non-spread sides and across the soft tissue.

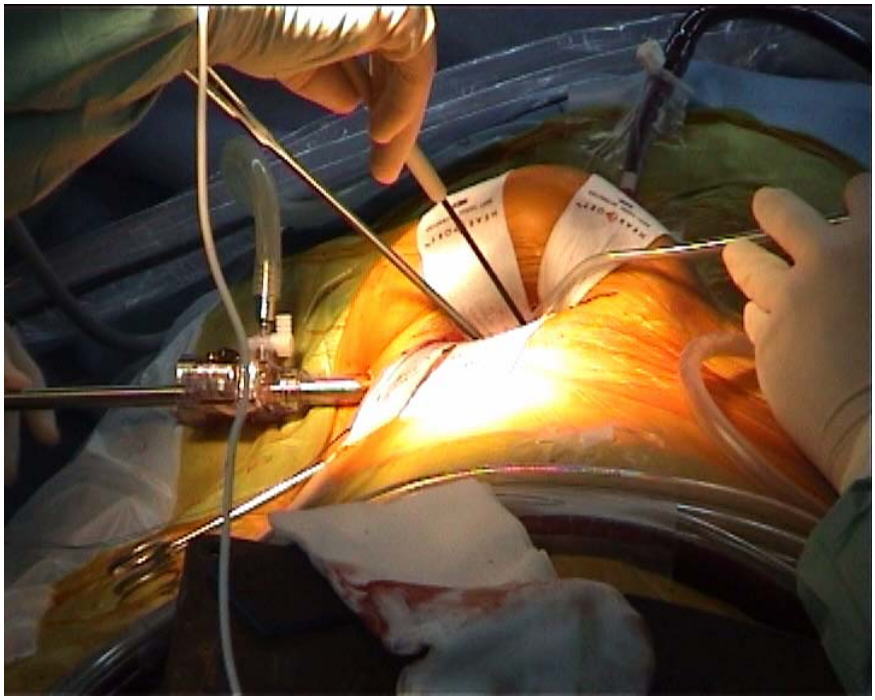
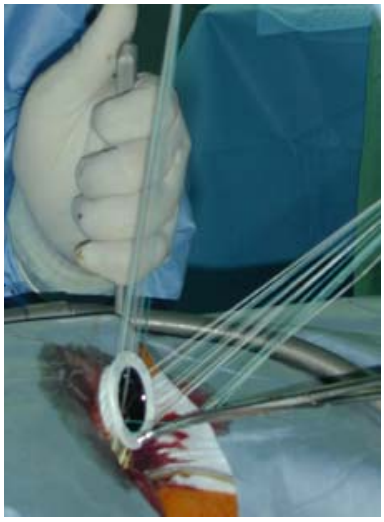


Fig. 17: Mitral procedure
Replacement or repair of the mitral valve.



Closure of the Left atrium by two 3/0 Prolene sutures. Purging and unclamping of the aorta. Introduction of Medtronic epicardial electrodes. Two size 24 drains (intrapericardial and intrathoracic) are introduced. They use the entry ports of the Chitwood clamp and the video lens. After cessation of extracorporeal circulation, jugular then femoral vein and artery decannulation. Protamine. Infiltration of the intercostal space with Novocaine before parietal closure.

- ***OPERATIVE RESULTS***

Fig. 18: Aesthetic appearance
For female patients, the incisions disappear into the fold under the breast.

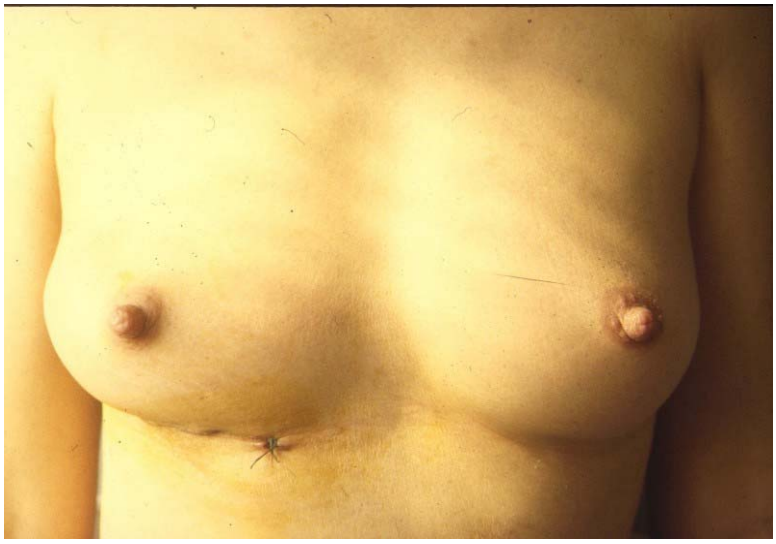
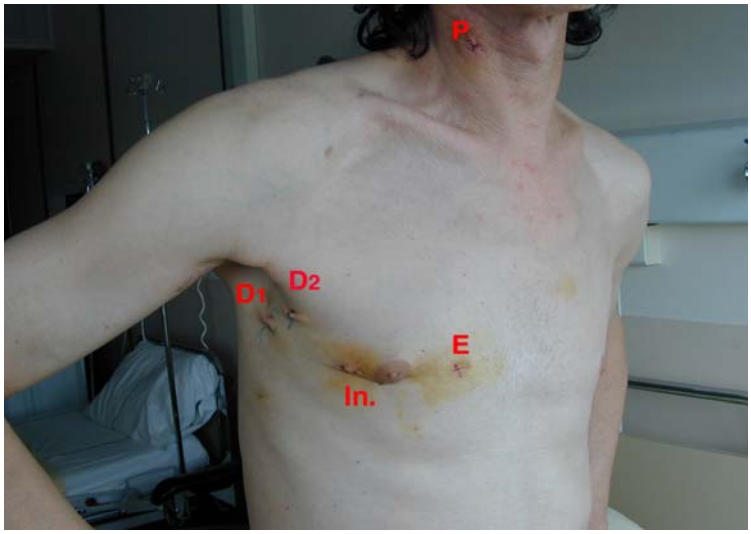


Fig. 19: Post-operative view the day after the intervention

P = jugular puncture port for extracorporeal circulation lines
D1 and D2 = Post-operative thoracic drain ports corresponding to the ports for pre-operative introduction of the aortic clamp and the video lens.
In = 4 cm incision at 4th intercostal space.
E = Outlet port for temporary post-operative epicardial electrodes, corresponding to the pre-operative port for the shaft of the mitral retractor.



Post-operative Management

* Bleeding is usually slight at 5 to 10 cc/hour, and the drains are removed the morning of the next day.
* AVK is restarted the next day in order to obtain early INR normalization and rapid discharge of the patient.
* Cordarone (Amiodarone Hydrochloride) is used for the first 15 days in order to reduce the risk of post-operative arrythmias. This is especially important in the case of short hospitalization and where the patient has already left the hospital.

RESULTS of the first 100 "learning curve" patients:

** The patients:*

One hundred and one patients were operated on, 21 in 2002, 42 in 2003 and 38 in the 1st quarter of 2004, the numbers gradually doubling each year. There were 28 females and 73 males aged from 29 to 83 years, presenting with 77 mitral insufficiencies, 17 rheumatic mitral valve disease, 4 cardiac tumors (3 myxomas of the left atrium, 1 thrombus of the right atrium) and 3 patients with endocarditis on pacemakers. Caution led us to concentrate on simple repairs, with 93% of prolapses restricted to P2 among all the valves repaired. In fact, in this initial experiment, the commissural or complex problems of the anterior lamina were considered contra-indicated to the minimally invasive approach. The average ejection fraction was 67% (47 to 88%), with the telediastolic diameter extending from 54 to 74. There was no significant coronary artery disease, except for 2 patients who benefited from a hybrid procedure with angioplasty of one marginal vessel, followed 3 months later by mitral surgery.

* Results:

Death occurred in one case of a woman aged 78 years on a pacemaker who was operated on for endocarditis but died with right ventricular insufficiency after two months in intensive care.

Morbidity can be divided into two kinds:

- classic morbidity not linked to this new technique, 1 atrio-ventricular heart block, 2 episodes of haemostasis, 2 re-admissions, 1 for pleural effusion and 1 for pericardial effusion associated with side effects of AVK, 1 peri-operative electrical and enzymatic infarct without clinical consequences, and one post-operative infarct with temporary left ventricular dysfunction;
- morbidity associated with the technique involved 7 lymphoceles of the groin, and 3 sub-cutaneous emphysemas. Two conversions to sternotomies were necessary towards the end of extracorporeal circulation to control haemostasis, but these had no clinical consequences for the patient. These complications, which occurred at the start of our study, have virtually disappeared today. Finally, there was one incidence of aortic insufficiency from a probable injury to the semilunar valve of the heart when introducing the sutures of the mitral ring. This patient has had subsequent aortic insufficiency but this is clinically insignificant now, after gradually diminishing for 18 months. Four conversions were decided on immediately because of difficulties during peripheral cannulation.

* Post-operative developments:

The results improved rapidly, with significant reduction in pain and aesthetic improvements. Only 13% of patients received transfusions, generally because they were already anaemic when they arrived for surgery. However, the expected early discharge of patients was not always possible because the registration procedures were not easy to modify. In the case of patients with damaged leaflets, valvular competence was excellent and permanent, without significant residual mitral insufficiency, and with rapid ventricular remodeling as was expected in this population selected for simple mitral valve repair.

Short-term secondary follow-up confirmed the excellent quality of the procedures carried out, both for simple procedures such as removal of a tumor or valve replacements and for repairs. To date, secondary mortality has been zero, though monitoring is still in the early stages. Post-operative echocardiography of the 82 repairs carried out showed 75 grade 0 or 1 mitral insufficiency, 6 grade 2 mitral insufficiency and one grade 3 mitral insufficiency. The success in correcting simple degenerative lesions leading to mitral insufficiency such as isolated P2 prolapse was constantly high and comparable to the results obtained by sternotomy. The only significant grade 3 residual mitral insufficiency related to a pellucid-type dystrophic mitral insufficiency where there was no dilation of the ring, with a satisfactory pre-operative echocardiography and disappointing control until the 48th hour, with an apparent tear at the attachment site in the meantime which, in the context of a pellucid valve, is more likely to be related to the nature of the tissues than to the access route which had suggested a technical procedure under favorable conditions.

DISCUSSION:

Hugo Vanermen (Aalst, Belgium) is a true pioneer who defined the basic techniques for this minimally invasive mitral approach. F. Mohr (Leipzig, Germany) and R. Chitwood (Greenville, USA) have also made early contributions. The technical obstacles which were initially considerable, partly because of the use of the aortic endoclamp with its risk of aortic dissection, have been overcome. The development of materials and the definition of procedures which have been simplified and made less expensive, today allow wider usage of this technique.
The development of minimally invasive surgery in the field of cardiology has been the subject of numerous publications and efforts (with varying degrees of success) to make major advances in recent years, whether in coronary revascularization with a beating heart, or minimally invasive coronary revascularization with mastectomy aided by video or robot.

Of all these developments, mitral surgery assisted by video is undoubtedly among those offering the most promise from a technical point of view, for several reasons:

- *it allows access to the mitral valve which is more logical anatomically because it is more direct than using sternotomy;*
- *magnification of the exposed valve by the video zoom provides an optimal view;*
- *repair procedures are reproducible using video much more easily than micro-surgical procedures such as those needed for coronary sutures;*
- *removal of bubbles is complete thanks to the use of CO2 in this almost sealed thoracic cavity and seems from the evidence to be greatly superior to bubble removal using sternotomy, where multiple micro-bubbles are clearly visible in pre-operative extended trochanteric osteotomy; it promises hope of better preservation of cognitive functions post extracorporeal circulation, and this should be confirmed at a later date;*
- *Increased information is encouraging us to operate on younger patients who often have none or fewer symptoms and for whom it is easier to suggest less aggressive surgery*

In the course of the progressive adoption of this technique, we assessed the potential benefits of the new approach. The aesthetic advantage of a small incision which is completely hidden in the fold under the female breast is clear. In addition, this parietal approach involving 4 to 6 cm is less painful now that the technique has been fully mastered and the surgeon no longer uses a retractor, and is the fruit of a slow and progressive, appealing learning curve.
Blood loss and peri-operative supra-ventricular arrythmias have reduced considerably. On the other hand, it is our experience that the periods of stay in intensive care and in hospital have not changed significantly. The entrenched regulations covering cardiac surgery mean that it is difficult to leave after less than a week's hospitalization, even though it has regularly been possible to send patients home after the 5th day. However, in patients with prophylactic indications and continuing left ventricular function, ventricular remodeling is rapid, with telediastolic diameters almost normal after a few days. In patients without parietal aggression and with a corrected valvulopathy and a normalized heart, return home can be allowed immediately, without the need for reeducation. Return to work or leisure activities can occur extremely quickly.

CONCLUSION:

After treating the first 100 patients, we now consider that we are emerging from the learning curve and that this technique will be used gradually as the preferred way of accessing the mitral valve for simple procedures such as valve replacements, tumor surgery, and simple degeneration of the posterior /valve leaflet. The increasing confidence that we have acquired now encourages us to treat more complex lesions affecting the anterior leaflet or left ventricular dysfunction. Even though the initial results are very encouraging, they should still be confirmed by long-term follow-up.
We are now convinced that this new technique should be used as a reference technique for mitral surgery, following the example of the adoption of video in gynaecological, thoracic or abdominal surgery.

Fig 20: 15-year-old male
Result 1 month after mitral repair for infectious endocarditis operated on in the acute phase.