Cardioscopy: potential applications and benefit in cardiac surgery

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Abstract

Objective: Cardioscopy in open heart surgery is still not routine in most units. However, since our first report in 1996 we use this device more frequently, because we think that safety and accuracy of different surgical procedures is increased. Methods: Between 1/96 and 12/97 we performed cardioscopy in 100 patients. Indications (IND) for cardioscopy were as follows: IND (1) resection of hypertrophied septum (N = 15); IND (2) evaluation of aortic valve with low grade stenosis or insufficiency (N = 12); IND (3) removal of intracardiac foreign bodies/tumors (N = 13); IND (4) inspection of VSD prior and after repair (N = 8); IND (5) identification of paravalvular leakage (N = 8); IND (6) diagnostic purposes (N = 4); IND (7) education of surgeons and operating room staff (N = 40). During cardioplegic arrest the 5 mm rigid or flexible cardioscope (Storz®, Tuttingen, Germany) was inserted through ascending aorta, aortic valve or tricuspid valve depending on indication. Results: No complication occurred during cardioscopy. IND (1): there was an excellent view of all intracardiac structures. Thorough resection of hypertrophied septum was possible and there was no injury of adjacent structures or aortic valve. IND (2): all valves were inspected through a 1 cm aortic incision and the pathology of the valves was documented. In case of severe calcification, the valve was replaced although transvalvular gradient was less than 50 mm Hg. IND (3): intraventricular foreign bodies, such as felt pledges (N = 2), debris (N = 5), thrombi (N = 4) and tumors (N = 2) were entirely removed through the aortic valve with a special forceps. IND (4): anatomy of VSD was documented in all cases. It was possible to test accuracy of all patch-sutures. IND (5): all paravalvular leakages were identified eventhough there was heavy immobility of the mechanical valve. IND (6): a papillary muscle (N = 2) and a thrombus formation (N = 2) were diagnosed. IND (7): the surgeons and operating room staff could follow the entire procedure in all cases. Conclusions: Cardioscopy is a supporting technique to clearly identify intracardiac structures, to control several surgical procedures, to document valve pathology, and to educate surgeons and operating room staff. Handling is easy and does not increase operative risk. Some procedures will be performed with minimal invasivity in future. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Endoscopy; Cardiac surgery; Minimal invasive

1. Introduction

The moving heart and the bloody surgical field were the main reasons why endoscopic techniques in cardiac surgery did not develop as fast as in abdominal surgery. For this reason, cardiac endoscopy was used primarily in the more or less bloodless and immobile pericardium. The first endoscopic intervention was performed in 1986 for diagnosis of intrapericardial pathologic structures [1]. The first therapeutic procedures such as pericardectomy and complex pericardial fenestration were carried out the same year [2,3]. Several authors described placement of the optical device and the endoscopic instruments used for subxiphoidal and transthoracic approach [2,4–6]. Ligature of patent ductus Botalli and division of vascular rings was described in the early nineties [5,6]. Results were identical as compared to conventional surgery. However, there was less postoperative pain and early mobilisation of the patients was possible. The only disadvantage of endoscopy in these cases was longer operative time. Beating heart endoscopy was used later on for tricuspid valve evaluation and diagnosis of intra-ventricular mural thrombus [7–9].

Therefore a balloon-covered flexible endoscope was percutaneously inserted into a femoral vein for right heart investigations and into a femoral artery for left heart investigations. By filling the balloon with crystalloid saline and touching the myocardial wall with the tip valve failures, thrombi, ventricular septal defects or aneurysms were diagnosed. However, hemodynamic instability and induction of arrhythmias were observed during this procedure [10].

Our primary intention to use an endoscope (cardioscope) in heart surgery was to better visualise intracardiac struc-
tures such as the left and right ventricular cavity which are hardly visible for the surgeon without ventriculotomy. With time there was a wider use of the cardioscope since no complications occurred.

### Table 1

<table>
<thead>
<tr>
<th>Indication for cardioscopy</th>
<th>n = 100</th>
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<tbody>
<tr>
<td>Aortic valve evaluation</td>
<td>n = 12</td>
</tr>
<tr>
<td>Resection of hypertrophied tissue</td>
<td>n = 15</td>
</tr>
<tr>
<td>Removal of foreign bodies/tumours</td>
<td>n = 13</td>
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<tr>
<td>Diagnostic purposes</td>
<td>n = 4</td>
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<tr>
<td>Inspection of VSD</td>
<td>n = 8</td>
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<tr>
<td>Identification of paravalvular leakage</td>
<td>n = 8</td>
</tr>
<tr>
<td>Educational purpose, intraoperative validation of diagnosis</td>
<td>n = 40</td>
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</tbody>
</table>

2. Method

When cardioscopy was expected prior to surgery the patients were informed preoperatively. Either a rigid or a flexible scope was used (Karl Storz, Tuttingen, Germany). The tips of the 5 mm rigid cardioscope have different angles (0°, 30°, 70°) and were used as appropriate. The flexible scope is 4 mm in diameter and has a straight tip.

The optics are attached to a one-chip-camera, which is connected to an electronic control-system. With this system it is possible to adjust brightness and contrast. Using an optional digitizer, the edges of the display can be sharpened to enhance contrast. The light-cable is connected to a xenon-light source. The signal is transmitted to a SVHS-video recorder and a monitor.

Specially elongated instruments such as forceps, scissors or scalpells are used for therapeutic cardioscopic interventions. Flexible instruments facilitate the access to difficult areas.

![Fig. 1. Resection of hypertrophied intraventricular tissue in case of HOCM. By means of a forceps (left) the tissue is grasped and resected.](image1)

![Fig. 2. Evaluation of low grade aortic stenosis by means of specially shaped wire. Thus the leaflets can be checked for calcification and/or reduced mobility.](image2)

![Fig. 3. Removal of intraventricular felt pledges, hidden behind papillary muscle. By using a flexible forceps (left) the foreign body can be easily grasped.](image3)

![Fig. 4. Inspection of edges of VSD (centre of image). Thus the dimension and location of the defect can be evaluated.](image4)
Preparation of patients is made as usual. After median sternotomy and full-eparinisation extracorporeal circulation is established. The aorta is cross-clamped and heart arrest is induced via ante- and retrograde perfusion of cold blood-cardioplegia.

Depending on the type of operation, the cardioscope is inserted into atria and/or ventricles. If the tip of the scope contacts with tissue or blood, the optic is cleaned either by using a swab or by rinsing. Therefore a rinsing and suction device was developed. Through a small nozzle at the end of the device, saline is pressed directly onto the optic.

The surgeon and the nurse are placed on the right side of the table and both assistants on the left side. The mobile video-unit is positioned between the assistants. Adjustment of the camera is primarily done by the surgeon and the second assistant holds the endoscope in position.

2.1. Technique of cardioscopy

2.1.1. Inspection of the left ventricular cavity

The scope is either inserted through the aorta or left atrium depending on the type of operation. A small aortotomy (0.5–2 cm) is performed for diagnostic purposes, removal of thrombi, foreign bodies or tumors and resection of hypertrophied or fibrous intraventricular tissue. The aortotomy is larger when combined with the aortic valve operation. If the left ventricle must be inspected during the mitral valve operation, the scope is inserted through the mitral valve. It is advantageous to place a left heart vent in order to maintain a bloodless cavity. The angle of the optic is chosen as appropriate.

2.1.2. Inspection of right ventricular cavity

The scope is inserted through the tricuspid valve or sometimes through the pulmonary artery. In case of VSD repair either a 70° optic or a flexible scope is used.

3. Results

Indications for cardioscopy are depicted in Table 1.
3.1. Resection of hypertrophied or fibrous intraventricular tissue (Fig. 1)

In 15/100 (15%) the cardioscope was used for resection of pathologic intraventricular tissue. In seven cases there was isolated HOCM, in five cases asymmetric septum hypertrophy (ASH) combined with aortic stenosis and in three cases membranous subaortic stenosis, one combined with aortic stenosis. In nine cases without aortic stenosis, aortotomy was small (1.7 ± 0.6 cm), whereas a normal shaped aortic incision was performed in six patients. The elongated scalpel did neither injure papillary muscles nor chordae during cardioscopy. There was an excellent view of the entire septum in all cases. In four cases myocardial tissue falling into ventricular cavity during resection was removed with a forceps under cardioscopic control.

Intraventricular gradients of patients with HOCM and membranous subaortic stenosis decreased from 78 ± 3.2 to 4 ± 1.1. In all cases there was optimal view of the septum with the 30º angled optic, whereas the 0º angled optic was necessary to remove the myocardial tissue.

3.2. Evaluation of low grade aortic stenosis (Fig. 2)

In 12/100 (12%) patients cardioscopy was performed to evaluate aortic valve with a systolic gradient less than 50 mm Hg. All patients had combined CABG. Mobility of the leaflets was tested with a specially shaped wire. In eight patients there was heavy immobility or even calcification of two or three aortic valve leaflets and the valve had to be replaced. In four patients only one leaflet showed pathologic mobility and therefore valve was left in situ.

3.3. Removal of intraventricular foreign bodies (Fig. 3)

In 8/100 (8%) patients closure of a paravalvular leakage (two aortic, six mitral) was performed with cardiostatic support. One aortic leakage which was not diagnosed preoperatively was discovered during mitral valve reoperation. Three mitral anterolateral paravalvular leakages were hardly visible without the scope due to heavy pericardial adhesions. All leakages were closed with videoassistance and postoperative control showed no residual shunt in all cases.

3.4. Inspection of VSD (Fig. 4)

Patch-closure of VSD was carried out in 8/100 (8%) adult patients. It was possible to define the anatomical margin of the VSD and to view its vicinity structures including its aortic valve. In most cases a 70º angled scope was appropriate for this indication. The entire suture line could be checked under direct visualisation. Postoperative echocardiography showed adequate closure of the defect without residual shunt in all patients.

3.5. Identification of paravalvular leakage (Fig. 5)

In 3/100 (3%) patients closure of a paravalvlar leakage (two aortic, six mitral) was performed with cardiostatic support. One aortic leakage which was not diagnosed preoperatively was discovered during mitral valve reoperation. Three mitral anterolateral paravalvular leakages were hardly visible without the scope due to heavy pericardial adhesions. All leakages were closed with videoassistance and postoperative control showed no residual shunt in all cases.

3.6. Diagnostic cardioscopy (Fig. 6)

The cardioscope was inserted through the aortic valve during CAGB to evaluate intraventricular structures which were seen during echocardiography and in ventriculogram in 4/100 (4%) patients. A hypertrophied papillary muscle and a thrombus formation was diagnosed in two cases each. The thrombi were left in situ since they were old and fixed to the ventricular wall.

3.7. Education of surgeons and operating room staff, intraoperative validation of diagnosis (Fig. 7)

The cardioscope was used in 40/100 (40%) patients for educational purposes and intraoperative validation of diagnosis only (27 during mitral valve surgery, eight during minimal invasiv aortic valve replacement and 5 during aortic arch surgery). The surgeons and the operating room staff could follow the entire procedure in all cases. This supported the confirmation of preoperative findings, or lead to a change of the operative protocol. However, the assistants and the nurse had to be remembered from time to time to assist the surgeon, since they had their heads turned to the monitor.

4. Discussion

Our results show, that use of the cardioscope during open heart surgery is safe, since there was no tissue injury in any case. Out of our data we can not conclude that cardioscopy prolonged aortic crossclamp-time. Others think, that cardio-pulmonary bypass time and aortic cross-clamp time might be longer [4,5]. However, it is also possible that these times are shorter due to better visualisation of the operative field. Handling of the scope is easy to learn. However, it may interfere with other instruments and disturb the surgeon. In these cases, the cardioscope should be removed and repositioned if appropriate. When blood soils the optic it is cleaned by flushing Ringer solution through the rinsing device. We must confess, that the device needs some modification, since proper cleaning is not always possible. No complication occurred during cardioscopy. Others describe
potential problems such as valve laceration, ventricular or atrial wall perforation and conduction system contusion [5]. To prevent trauma the rigid cardioscope must be advanced along a straight anatomic path. If once the scope is in position it might be fixed by a special holder [11].

Video-assisted resection of hypertrophied and fibrous intraventricular tissue has been previously described by our group [12,13]. To our opinion the cardioscope should be used, whenever there is a significant subvalvular gradient. We think, that a more thorough resection of the septum is possible when performed video-assisted although this hypothesis is difficult to prove.

Mild aortic stenosis is often diagnosed during catherisation or echocardiography prior to CABG operation. It is well known, that mild aortic stenosis may aggravate within a few years with need of risky reoperation [14]. Thus, whenever there is suspicious aortic valve morphology we perform cardioscopy to evaluate the valve leaflets after completion of distal bypass anastomoses. If at least two of the leaflets are immobile and calcified the valve is replaced even if there is low systolic transvalvular gradient. We think that this strategy is justified in view of the high operative risk of aortic valve replacement after previous CABG [14].

Although foreign bodies such as debris and felt pledges should not fall into the ventricle during an operation it may happen. Without any doubt, the cardioscope helps to find such foreign material. If a mechanical valve is already in place it can be passed by the cardioscope. Since the scope is only 5 mm in diameter, there is no damage of the pyrolyte surface of the valve to be expected. In one of our cases a pledget fell into the ventricle during tying. The felt was removed through the mechanical valve by using the cardioscope and an elongated forceps. If this device would not have been available, the valve had to be totally removed. Endoscopic excision of an intraventricular tumor has been described previously [15]. As in our two cases it was a papillary fibroelastoma, which was excised by transaortic approach. There is a definite advantage to perform video assisted cardioscopy in such cases, since ventricular incision with potential complications is avoided. Others describe resection of a blood cyst in left ventricle resected by transaortic valve approach [16].

Video-assisted cardiac operations have already been performed in congenital heart surgery [4–6]. We perform cardioscopy whenever a congenital or ischemic VSD is diagnosed. Video-assistance might facilitate closure of VSD’s especially muscular VSD’s where surgical results using right atrial approach are frustrating. Left ventriculotomy to improve exposure of muscular VSD’s has produced a significant incidence of ventricular dysfunction, arrhythmias and aneurysm formation [4].

Identification of paravalvular leaks, e.g. of mitral valve is sometimes difficult particularly in the case of severe pericardial adhesions of the heart. Such adhesions immobilize the mitral prosthesis completely and anteromedial areas are often inaccessible. Cardioscopy with a 30° angled optic allows good exposure of this region.

If a pathologic structure is detected in the ventricular cavity prior to an operation diagnosis can be made by transvalvular cardioscopy. In two patients an intraventricular thrombus was diagnosed which was left in place. Left ventriculotomy has been a standard approach for removal of such thrombi. However, as stated above, ventriculotomy may produce severe complications. Others describe removal of a left ventricular thrombus with the cardioscope as well [16,17]. In one case, there was transaortic removal of a thrombus in a child [17].

There are certain types of cardiac operations which take place in areas not visible for the assistants and the nurses e.g., mitral valve surgery, congenital heart surgery or during minimal invasive procedures. Cardioscopy allows the assistants and nurses to follow the operation on the video screen. Video assistance is especially helpful when an inexperienced resident performs the operation, since senior surgeons can advise the operator in detail while watching the monitor. Others also think, that the use of the cardioscope improves education of operating room staff [11].

In conclusion cardioscopy is a supporting technique to clearly identify intracardiac structures to control several surgical procedures and to educate surgeons and operating room staff. With increasing experience ventriculotomies might become redundant. Further experience with cardioscopy might broaden its clinical applicability.

References

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Appendix A. Conference discussion

Dr. S. Westaby (Oxford, UK): I certainly agree with you that in hypertrophic cardiomyopathy being able to see well down into the ventricle is absolutely invaluable to get a good repair and to view mitral valve abnormalities. So I think that is one of the very best areas for the cardioscope at the moment.