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Video-assisted cardiac surgery: 6 years of experience

Cirurgia cardíaca videoassistida: 6 anos de experiência

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Abstract

Introduction: **Minimally invasive and video-assisted cardiac surgery (VACS) has increased in popularity over the past 15 years. The small incisions have been associated with a good aesthetic effect and less surgical trauma, therefore less postoperative pain and rapid recovery.**

Objectives: **To present our series with VACS, after 6 years of use of the method.**

Methods: **136 patients underwent VACS, after written consent, between September 2005 and October 2011, 50% for men and age of 47.8 ± 15, 4anos, divided into two groups: with cardiopulmonary (CEC) (GcCEC=105 patients): mitral valve disease (47/105), aortic disease (39/105), congenital heart disease (19/105) and without extracorporeal circulation (CEC) (GsCEC=31 patients): cardiac resynchronization (18/31), cardiac tumor (4/31) and minimally invasive coronary artery bypass grafting (6/31). GcCEC was held in right minithoracotomy (3 to 5 cm) and femoral access to perform cannulation.**

Results: **In GcCEC, mean length of ICU stay and hospital stay were respectively 2.4 ± 4.5 days and 5.0 ± 6.8 days. Twelve patients presented complications in post-operative and five (4.8%) death. Ninety-three (88.6%) patients evolved uneventful, were extubated in operating room, and remained a mean of 1.8 ± 0.9 days in ICU and 3.6±1.3 days in the hospital. In GsCEC, were mean 1.3 ± 0.7 days in ICU and 2.9 ± 1.4 days in hospital and without complications or deaths.**

Conclusion: **The results found in this series are comparable to those of world literature and confirm the method as an option the conventional technique.**

Descriptors: **Heart valves/cirurgia. Video-assisted surgery. Thoracic Surgery, Video-Assisted.**

Resumo

Introdução: **A cirurgia cardíaca minimamente invasiva e videoassistida (CCVA) tem aumentado em popularidade nos últimos 15 anos. As pequenas incisões têm sido associadas a um bom efeito estético e menor trauma cirúrgico, consequentemente, menor dor e rápida recuperação pós-operatória.**

Objetivos: **Apresentar nossa casuística com CCVA, após 6 anos de uso do método.**

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Abbreviations, acronyms & symbols	
VACS	video-assisted cardiac surgery
CPB	Cardiopulmonar bypass
DH	days in hospital
DICU	Days in ICU
GcCPB	Group with CPB
GsCEC	Group without CPB
ICU	Intensive care unit
TEE	Transesophageal echocardiography

Métodos: **Cento e trinta e seis pacientes foram submetidos à CCVA, após consentimento escrito, entre setembro de 2005 e outubro de 2011, sendo 50% do sexo masculino, com idade de 47,8 ± 15,4 anos, divididos em dois grupos: com circulação extracorpórea (CEC) (GcCEC=105 pacientes): valvopatia mitral (47/105), valvopatia aórtica (39/105) e cardiopatia congênita (19/105) e sem CEC (GsCEC=31 pacientes): ressincronização cardíaca (18/31), tumor cardíaco (4/31) e revascularização miocárdica minimamente invasiva (6/31). No GcCEC, foi realizada minitoracotomia direita (3 a 5 cm) e acesso femoral para canulação periférica.**

Resultados: **No GcCEC, a média de dias em UTI (DUTI) e de internação hospitalar (DH) foi, respectivamente, 2,4 ± 4,5 dias e 5,0 ± 6,8 dias. Doze pacientes apresentaram complicações no pós-operatório e cinco (4,8%) foram a óbito. Noventa e três (88,6%) pacientes evoluíram sem intercorrências, foram extubados no centro cirúrgico, permanecendo 1,8 ± 0,9 DUTI e 3,6 ± 1,3 DH. No GsCEC, foram 1,3 ± 0,7 DUTI e 2,9 ± 1,4 DH, sem intercorrências ou óbitos.**

Conclusão: **Os resultados encontrados nesta casuística são comparáveis aos da literatura mundial e confirmam o método como opção à técnica convencional.**

Descritores: **Valvas cardíacas/cirurgia. Cirurgia vídeo-assistida. Cirurgia torácica vídeo-assistida.**

INTRODUCTION

The minimally invasive cardiac surgery has increased in popularity over the past 15 years. The small incisions have been associated with a good cosmetic result and less surgical trauma, less pain and consequently rapid postoperative recovery. For some time, even these arguments do not attract the attention of the physician population. With the wider dissemination of technical and better results in recent reports, this concept has been changing. The benefits of smaller incisions are sustained mainly that the reduction in hospital costs, without prejudice to the results already achieved with median sternotomy [1-3].

Incorporating the minimally invasive techniques, even in recent years, endovascular procedures took popularity. In these examples, are included the aortic stents, devices for occlusion of congenital clefts (Amplatzers) and transcatheter aortic valve implants [4-8].

Still, the median sternotomy is still the traditional approach for surgical treatment of heart disease because it allows excellent control of all cardiac structures, asserting itself as a safe technique with low morbidity.

All surgical options have recently shown that incorporated technological developments allied to medicine has great scientific value, and despite the good results achieved with conventional procedures, they should not be ignored [9].

The aim of this study was to try to gather all the cases who underwent cardiac surgery at our institution with minimally invasive and video-assisted (VA) interventions and disseminate the results of in-hospital period.

METHODS

One hundred and thirty-six patients underwent VACS, between September 2005 and October 2011, after informed about the alternative procedure and signed written informed consent. Sixty-eight (50%) patients were male and mean age was 47.8 ± 15.4 years. In this series, with the intention of enabling better homogenization of the disease, patients were divided into two groups: those with cardiopulmonary bypass (GcCPB) and without use of CPB (GsCPB). One hundred and five patients underwent cardiac surgery with CPB and cardiotomy and the remaining 31 patients underwent procedures on the peropheral area of the heart, without cardiotomy.

On GcCPB group, 35% of patients had mitral valve disease, 29% aortic and 14% congenital heart disease. In group GsCPB, 18 (13%) patients had dilated cardiomyopathy and underwent cardiac resynchronization therapy, three patients underwent correction of coronary-pulmonary fistula by thoracoscopy (without CPB), four patients underwent endoscopic resection of tumor involving the heart (3%) and six underwent minimally invasive CABG with dissection of left internal mammary artery via thoracoscopy (4%). All clinical characteristics of patients in this sample were included in Table 1.

Table 1. Clinical characteristics of patients undergoing primary VACS distributed by pathology and given their numbers and percentages of presentation. (M=mean, sd=standard deviation, n = number,% = percentage, EF = ejection fraction)

	All		Mitral		Aortic		Congenital		TRV		Cardiac tumor		CABG	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Number	136	100%	47	35%	39	29%	22	16%	18	13%	4	3%	6	4%
Age (m + dp)	47.8	15.4	46.5	13.7	54.4	13.7	29.6	14.7	57.2	9.4	37.3	11.5	57.8	8.7
Age>65 years	23	17%	9	19%	9	23%	0	0%	4	22%	0	0%	1	17%
Male	68	50%	16	34%	26	67%	5	23%	12	67%	2	50%	4	67%
Female	68	50%	29	62%	9	23%	17	77%	6	33%	2	50%	2	33%
(NYHA) Functional Class														
I	15	11%	7	15%	1	3%	4	18%	0	0%	0	0%	0	0%
II	66	49%	19	40%	24	62%	12	55%	0	0%	4	100%	3	50%
III	44	32%	18	38%	14	36%	6	27%	10	56%	0	0%	3	50%
IV	11	8%	3	6%	0	0%	0	0%	8	44%	0	0%	0	0%
Comorbities														
Hypertension (HAS)	63	46%	18	38%	27	69%	7	32%	6	33%	0	0%	5	83%
Diabetes mellitus (DM)	20	15%	3	6%	4	10%	4	18%	7	39%	0	0%	2	33%
Atrial fibrillation (FA)	25	18%	16	34%	3	8%	1	5%	6	33%	0	0%	0	0%
EF<56%	33	24%	5	11%	8	21%	0	0%	18	100%	0	0%	3	50%
Prior reopeartion	4	3%	4	9%	0	0%	0	0%	0	0%	0	0%	0	0%
Endocarditis	3	2%	3	6%	0	0%	0	0%	0	0%	0	0%	0	0%
Emergency surgery	4	3%	4	9%	0	0%	0	0%	0	0%	0	0%	0	0%
Primary pathology														
Failure	52	38%	35	74%	19	49%	0	0%	0	0%	0	0%	0	0%
Stenosis	32	24%	12	26%	20	51%	0	0%	0	0%	0	0%	0	0%
Rheumatic	54	40%	33	70%	25	64%	0	0%	0	0%	0	0%	0	0%
Degenerative	25	18%	14	30%	9	23%	0	0%	0	0%	0	0%	0	0%
Congenital	27	20%	0	0%	5	13%	22	100%	0	0%	0	0%	0	0%
Pulmonary coronary fistula	3	2%	0	0%	0	0%	3	14%	0	0%	0	0%	0	0%

Echocardiographic, peripheral vascular doppler, abdominal aorta and carotid arteries assessments were performed in all patients who required peripheral CPB. Coronary angiography was performed in patients with cardiovascular risk compatible with the possibility of coronary disease. We excluded from this study patients with concomitantly moderate to severe aortic insufficiency indicated for mitral valve surgery, severe peripheral vascular disease requiring peripheral CPB, previous thoracic surgery on the same side of the surgical procedure, concomitant surgical coronary artery disease or who opt for the median sternotomy. In other cases, the first option was always the VACS.

In Group GcCPB was performed right minithoracotomy (3-5 cm), on the 3rd or 4th right intercostal space, according to the atrioventricular or aortic disease involved and peripheral cardiopulmonary bypass, performed by the femoral vessels (port-access technology) [10.11]. Left thoracoscopy was performed in cases of cardiac resynchronization therapy, CABG, or that required the same surgical approach.

Transesophageal echocardiography (TEE) was used in all patients from GcCPB both for introduction of the arterial and venous cannulas, and for monitoring and confirmation of the surgical, valvular or congenital outcome.

The instruments used involved a thoracoscope with a diameter of 5 or 10 mm according to the need for visual field and lens angle of 30 degrees. The instrumental (ESTECH ® Inc., California, USA) specifically designed for cardiac surgery, included: atrial retractors, scissors, knot pushers, aortic clamp, needle holder and needle holder.

Other instruments such as forceps, electrocautery, video cameras and light source were the same used in conventional laparoscopy. In cases in which CPB was used, were used: a CO_2 insufflator to replace the air, and a negative pressure manometer for venous vacuum drainage. The kits for femoral, arterial and venous cannulation, designed for peripheral CPB, were used in all these cases (DLP ®, Medtronic Inc., Minneapolis, USA).

Step-by-step of surgical technique in cases of VACS with peripheral CPB

1. At least two peripheral accesses of good caliber were used to induce anesthesia;

2. Endotracheal intubation was performed using Carlens® or Portecs® cannulas to occlusion of the right lung during surgery;

3. After insertion of the cannula, the team has ensured the effective right unilateral occlusion and maintenance of oxygenation with a single lung;

4. It was required cannulation of both radial arteries with the aid of aortic endoclamp, allowing monitoring of endoclamping, so it does not migrate and occlude the great vessels. In cases of transthoracic aortic clamping, a radial artery was sufficient;

5. Central vessel, subclavian or jugular vein puncture for drug infusion and central venous pressure monitoring. It was always preferable the puncture of the right side, because an undiagnosed complication as pneumothorax on the left side can be very serious and to prevent occlusion of the right lung;

6. Adhesive transthoracic defibrillation paddles were placed in the left thoracic region, anterior and posterior;

7. In cases with CPB, the right hemithorax and the femoral vessels were exposed by surgical fields. A pad slightly elevated the right hemithorax, so the midaxillary line would be exposed (Figure 1);

8. CPB was mounted in a conventional manner, vacuum system was tested with the aid of a negative pressure gauge connected to the venous reservoir of the oxygenator. This test was performed during filling of the circuit and removal of bubbles. Variations of 40-100 mmHg were used to allow adequate venous drainage;

Fig. 1 – Surgical position and peripheral accesses. Above: a supine position with slight elevation of the right hemithorax and exposure of the femoral vessels. Left: Minimum Dissection of the left femoral artery (iris retractor) to insert the cannula. Right: femoral puncture for percutaneous passage of the femoral venous cannula

9. After choosing the method of peripheral access, the femoral vessels were dissected and punctured, before heparinization (Figure 1). The CPB tubes directed to the operative field, positioned in the lower limbs;

10. The thoracic incision was initiated, after setting the best place to access. This ''incision is performed in skin and subcutaneous tissue. In women, it was preconized to anticipate with a marking pen, the inframammary incision site that is diverted from the recumbent for introduction of the trocar, initially used by the video camera to assist the optimal intercostal incision. The same trocar was used to place the left atrial vacuum and, at the end of surgery, of the chest tube;

11. Thus, the pericardium was dissected and phrenic nerve was identified. The pericardium was opened, before the nerve from the inferior vena cava to the aorta, near the sternal notch. In case of access to the aortic valve, the pericardium was incised higher, going down only until the view of the right atrium. Points of exposure were used to keep the pericardium open and pulled the chest wall;

12. After full heparinization, cannulation was performed of the femoral vessels, primarily the femoral vein, introducing a rigid metal guide wire, progressing to the right atrium, confirmed by TEE. Dilators were sequentially inserted to dilate the vessel until the cannula with occlusive dilator was introduced to the right atrium, again it was necessary to ensure its position with TEE. After the venous cannula positioned, this was fixed in the skin and connected to the venous CPB tubing. The same procedure was followed with the arterial cannulation, only that in this case, the progression of the cannula followed until its maximum length, in the abdominal aorta. This was connected to the arterial segment in the CPB tube, the permeability and pulse were tested;

13. In cases of right atriotomy (atrial septal defect, ventricular septal defect or mitral valve surgery by transseptal access), a double-stage cannula No. 22F (ESTECH ®) was introduced through the femoral vein with the aid of TEE, to its placement in the superior vena cava, followed by ligation of both venae cavae. In many cases, we used the double cannulation, superior vena cava with cannula No. 16F or 17F and inferior vena cava No. 21F, both DLP®. The option of double cannulation was always preferred, because the double-stage cannula, in some situations, due to its presence on the surgical field hinders the visualization of cardiac injury;

14. A 2cm incision was performed in the second intercostal space with anterior axillary line, for placing of the transthoracic clamp Chitwood® (Figure 2);

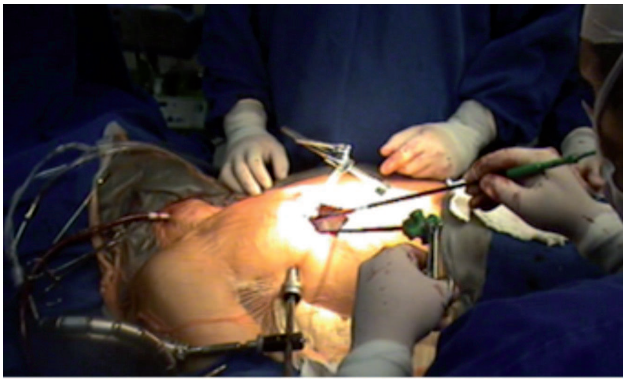

Fig. 2 - Panoramic view of mitral valve surgery. One should note the double cannulation with the inclusion of a cannula in the jugular vein. Thoracoscope fixed by arm and long instrumental penetrating through minimal incision

15. At this time, CPB was initiated. The need for higher or lower drainage was driven by the surgeon, who requested variations in vacuum pressure;

16. Before transthoracic clamping, it was made a purse in the aortic root to the introduction of cardioplegia cannula, which was used after the procedure also to remove air from the left cavities. This same cannula was removed always in CPB with low flow in order to minimize the risk of aortic dissection;

17. Hypothermic blood cardioplegia 4/1 was performed every 15 minutes and the CPB maintained between 28 and 30 degrees. In cases where it is used HTK solution (Custodiol ®), only one infusion was performed in the aortic root to perform the whole procedure, in case of aortic failure, the infusion into the coronary ostia was performed [12];

18. At that time, the heart cavity was opened, left atriotomy, septostomy, right atriotomy or aortotomy according the heart disease. Points of exposure were used for aorta and right atrium and left atrial retractor (ESTECH ®), in mitral disease;

19. After completing the main surgical time, we tried to be very careful for maximum removal of air from the cardiac cavities, also guided by TEE. The first step was to accomplish the full Trendelenburg position. In aortic diseases, the cardioplegia cannula, attached to the aortic root, was enough to aspirate all the residual air in the left ventricle. For the mitral valve, a "vent" of the left ventricle was placed through the valve, keeping it insufficient. At this time, TEE confirmed the complete elimination of air cavities of the heart, before the end of CPB. Periods of interruption of CPB with constant aspiration of the aortic root helped deaeration;

20. A chest drain was enough to drain, placed in the inferior incision initially used for suction of the left atrium.

21. After review of hemostasis, administration of protamine by continuous infusion was initiated. Before completion of the reversal of heparin, the venous cannula was removed. Considering that the inroduction was usually percutaneous, only local compression was performed;

22. After reversed anticoagulation, a 4-0 prolene purse was made in the artery around the femoral cannula for occlusion after its removal;

23. Finished all sutures, the anesthesia was superficialized and, where possible, the patient was extubated in the operating room.

RESULTS

One hundred and thirty-six patients underwent VACS. Thirty-one patients were not operated on using CPB (GsCPB), and 105, CPB and cardiotomy were used (GcCPB), and surgical procedures in this group are presented in Table 2.

Table 2. Surgical technique used in patients undergoing VACS with CPB.

GcCPB	N	%
Total	105	100.0%
Mitral	47	44.8%
Valvuloplasty	39	83.0%
Valve replacement	8	17.0%
Metallic prosthesis	7	14.9%
Bioprosthesis	1	2.1%
Tricuspid valve	6	12.8%
Transseptal access	32	68.1%
Exclusion of the left atrium	16	34.0%
Ablation of pulmonary veins	10	21.3%
Aortic	39	37.1%
Valve replacement	39	100.0%
Metallic prosthesis	33	84.6%
Bioprosthesis	6	15.4%
Ministernotomy	9	23.1%
Congenital	19	18.1%
Primary septoplasty	14	73.7%
Septoplasty with pericardial patch (IVC)	3	15.8%
Reconstruction of the atrial septum	2	10.5%

IVC = interventricular communication

On-pump group (GcCPB)

Most patients (101/105) underwent transthoracic clamping using Chitwood® clamp (ESTECH Inc., California, USA). In four cases, all underwent mitral reoperation, we used alternatives to transthoracic clamping, three patients underwent moderate hypothermia for cardiac arrest with ventricular fibrillation and one patient underwent endoclamping with aortic cannula ESTECH®. The first series of 61 patients receiving cold blood cardioplegia 4/1, intermittently, in the aortic root every 15 minutes, in cases of severe aortic regurgitation, the coronary ostia were used for selective infusion. In the last 37 patients we used a single infusion of Custodiol® solution in the aortic root or coronary ostia, as the disease involved. We opted for this solution due to the convenience of a single dose and its good response on ventricular function [12].

Mitral valve disease

Forty-seven patients received mitral valve surgery and there were performed eight (17%) valve replacement, 39 (83%) plasties, 10 (21.3%) modified Maze surgery and six (12.8%) tricuspid valve plasties. In valve replacement were used metallic prostheses (St Jude Medical System®) and were included patients with mitral lesion, with a predominance of severe stenosis. In the remaining 39 patients, a mitral valve repair was possible, and included commissurotomy and papillotomy, in cases of pure stenosis and implantation of Gregori's ring®, commissurotomy, quadrangular resection of posterior leaflet and/or transposition of chordae in cases of predominant mitral regurgitation. Radiofrequency ablation of pulmonary veins and exclusion of the left atrium (modified Maze) was performed in cases of atrial fibrillation associated. One patient with atrial septal defects and atrial fibrillation also underwent ablation of pulmonary veins and right atrium (Full Maze). Tricuspid valve with annular reduction was performed concurrently with the treatment of mitral valve in six patients. In the last 32 (68.1%) patients, we opted for transseptal access for treatment of mitral valve, as we noted better results than the transatrial access performed in the first patients.

One patient in the group of mitral valve disease underwent aortic and mitral replacement, due to significant aortic regurgitation, underestimated by echocardiography and that made it difficult to antegrade cardioplegia, being performed in the coronary ostia after the aortotomy. Three patients underwent surgery due to mitral valve endocarditis, two cases in a state elective and one urgent case for acute mitral regurgitation and embolic stroke.

In patients with mitral valve disease or congenital heart disease, we performed right minithoracotomy of 3-5 cm in the fourth left intercostal space, in these cases we chose the inframammary or periareolar access, as the anatomical possibility and physical constitution [13,14] (Figure 3).

Fig. 3 - Options for surgical incisions to access the mitral valve. From left to right: inframammary, periareolar, transareolar

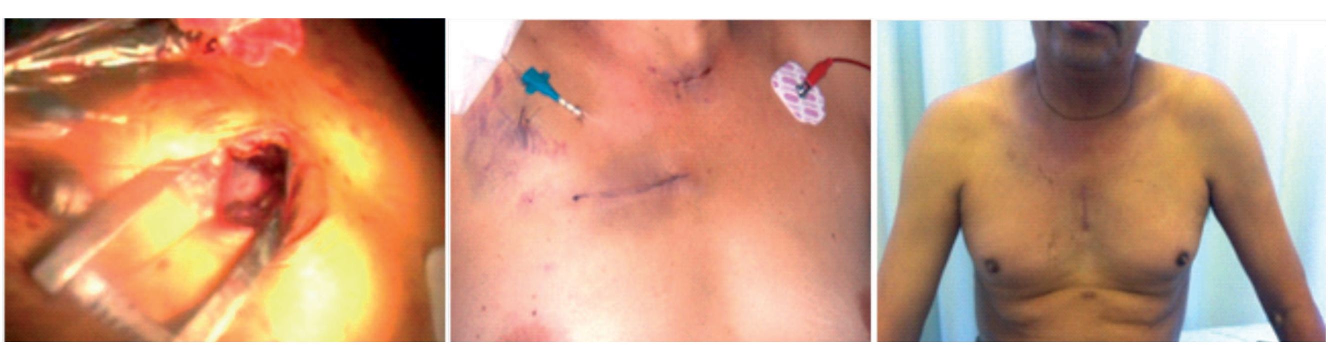

Fig. 4 - Options for surgical incisions to access the aortic valve. From left to right: exposure of the second intercostal with anterior axillary line and thoracoscopic trocar. Anterolateral right thoracic incision, high midline incision for superior hemisternotomy

Aortic valve disease

In 39 cases with aortic disease, valve replacement was performed in all patients. We decided 33 cases by the implantation of metal prosthesis (St. Jude Medical ® System). Six patients aged over 70 years underwent implantation of a bioprosthesis (Braile Biomedica ®). Upper inverted L ministernotomy was performed in nine patients, because they had important valvular calcification and dilatation of the ascending aorta. In other cases (76.9%, 30/39), we performed right anterolateral minithoracotomy through the second or third intercostal space (Figure 4).

Congenital heart disease

Nineteen patients had congenital heart disease, 16 had interatrial communication, of these 14 were treated with primary raffia. The inclusion of bovine pericardium was performed in only two cases, it was found complete absence of the atrial septum. Three patients had perimembranous ventricular septal defect which was closed with bovine pericardium for access through the right atrium by crossing the tricuspid valve, in these patients two presented associated interatrial communication and were corrected by primary suture.

Off-pump group (GsCEC)

Ventricular Resynchronization Therapy

Eighteen patients with dilated cardiomyopathy, refractory heart failure and severe ventricular dyssynchrony underwent cardiac resynchronization therapy. In such cases, in one was implanted biventricular resynchronization. Implantation of epicardial left ventricle was performed through left thoracoscopy. The preoperative orientation of the ideal position of the epicardial electrode and the postoperative control of resynchronization was performed using three-dimensional echocardiography (echocardiography IE-33, Philips Medical System). In all cases, the resynchronization was effective and without complications [15].

Coronary-pulmonary fistula

Three patients not included in the GcCEC group had coronary-pulmonary fistula treated with ligation through thoracoscopy and metallic devices [16].

Cardiac tumor

Resection of extracardiac tumor (lipoma) attached to the left atrium was performed in two cases, one with 1 kg of weight. A case of neurohemangiolipoma adhered to the pericardium and epicardium was also resected via thoracoscopy. The fourth patient had myasthenia gravis and thymoma, which was attached to the vessels and was also resected by thoracoscopy without thoracotomy.

CABG

Six patients underwent coronary artery bypass grafting for anterior descending coronary artery and implantation of left internal mammary artery. The surgical procedure was performed in the first time with thoracoscopy and thoracic artery dissection. Then minithoracotomy was performed in 4 th left intercostal space, with inframammary incision for the coronary implant. In all cases, was used intracoronary conduit without cardiopulmonary bypass. No patient had complications and all patients were discharged early.

Surgical and postoperative complications

The operative times and postoperative complications have been described in cases on which CPB was used associated with smaller incisions and are listed in Tables 3 and 4.

Table 3. Operative and postoperative times in patients undergoing VACS with CPB. Total and divided by the primary disease. (M=mean, sd=standard deviation, n=number, % = percentage, PO=postoperative)

	All		Mitral		Aortic		Congenital Heart Disease	
	Mean/N	%/sd	Mean/N	%/sd	Mean/N	%/sd	Mean/N	%/sd
Numver (n/%)	105	100%	47	44.8%	39	37.1%	19	18.1%
CPB/min.	134.1	58.8	147	55.3	143.7	59.2	85.1	37.5
Aortic clampiong/min.	82.2	39.6	91.9	42.3	87.8	30.9	45.5	27.5
Surgical room/min.	274.5	58.8	290	60.7	272.4	61.3	237.2	33.3
Extubation in the operating room	95	90.5%	41	87.2%	36	92.3%	18	95%
Time of ICU/days	2.4	4.5	3	6.5	2.4	1.8	1.3	0.5
PO hospital stay/days	5.0	6.8	5.6	8.8	5.5	5.4	2.6	0.8

Table 4. Operative and postoperative complications in patients undergoing VACS with CPB. Total and divided by the primary disease. (M=mean, sd=standard deviation, n=number, %=percentage, stroke)

	All		Mitral		Aortic		Congenital Heart Disease	
Total (n/%)	Mean/N	%/sd	Mean/N	%/sd	Mean/N	%/sd	Mean/N	%/sd
Complications and deaths	105	100%	47	44.8%	39	37.1%	19	18.1%
Stroke	12	11.4%	5	10.6%	6	15.4%	1	5.3%
Peripheral vascular injury	3	2.9%	0	0.0%	3	7.7%	0	0.0%
Dissection of the atrioventricular	1	0.95%	0	0.0%	1	2.6%	0	0.0%
groove	1	0.95%	1	2.1%	0	0.0%	0	0.0%
Aortic dissection	3	2.9%	0	0.0%	3	7.7%	0	0.0%
Pulmonary hemorrhage	2	1.9%	2	4.3%	0	0.0%	0	0.0%
Chest drain/ml	523.58	560.2	497.8	457.6	605.13	679.47	428.57	524.54
Blood products/units	0.98	1.47	1.04	1.53	1.13	1.56	0.57	1.08
Interventions								
Conversion to sternotomy	3	2.9%	1	2.1%	2	5.1%	0	0.0%
Reoperation for bleeding	5	4.8%	2	4.3%	2	5.1%	1	5.3%
Death	5	4.8%	3	6.4%	2	5.1%	0	0.0%

Table 5. Comparison of patients with and without in-hospital complications from GcCPB group, including preoperative clinical data and peri- and postoperative occurrences (m=mean, sd=standard deviation, n=number,%=percentage, EF = ejection fraction, min=minutes, PO=postoperative ag=age, AF=atrial fibrillation, ASH = hypertension, CPB = cardiopulmonary bypass, DM=diabetes mellitus)

	All		With complications		Without complications	
	Mean/N	SD/%	Mean/N	SD/%	Mean/N	SD/%
Number	105	100%	12	11.4%	93	88.6%
M	50	48%	7	58.3%	43	46.2%
F	55	52%	5	41.7%	50	53.8%
Ag	46.0	16.40	56.8	13.2	44.7	15.9
I	21	20%	0	0.0%	21	22.6%
II	38	36%	1	8.3%	37	39.8%
III	41	39%	8	66.7%	33	35.5%
IV	5	5%	3	25.0%	2	2.2%
Ag >65 years	18	17%	4	33.3%	14	15.1%
EF<56%	13	12%	6	50.0%	7	7.5%
ASH	51	49%	8	66.7%	43	46.2%
DM	13	62%	1	8.3%	12	12.9%
AF	19	18%	4	33.3%	15	16.1%
Mitral	47	261%	5	41.7%	42	45.2%
Aortic	39	37%	7	58.3%	32	34.4%
Congenital	19	18%	0	0.0%	19	20.4%
Thoracic drain	523.6	560.2	1480.0	966.40	438.20	403.70
Units/blood	0.98	1.47	3.8	1.50	0.70	1.10
CPB/min	134.1	58.8	215.2	68.7	122.8	48.2
Aortic clamping/min	82.2	39.6	129.3	42.7	76.7	35.6
Surgical room/min	274.5	58.8	365	65	261.6	46.6
Extubation in surgical room/min	95	90.5%	6	50.0%	91	97.8%
Time of ICU/days	2.4	4.5	3	6.5	1.8	0.9
PO hospital stay/days	5.0	6.8	5.6	8.8	3.6	1.3
Death	5	4.8%	5	41.7%	0	0.0%

The average surgical time was 274.8 ± 58.8 min in the operating room, 134.1 ± 58.8 min of CPB and 82.2 ± 9.6 3 min of aortic clamping. The total time of hospitalization accounted for 2.4 ± 4.5 days in ICU and 5.0 ± 6.8 days of postoperative hospital stay. The average total bleeding measured by chest drains in the postoperative, was 523.5 ± 560.2 ml and replacement of blood products was 0.98 ± 1.47 units of packed red cells per patient.

Twelve (11.4%) patients presented postoperative complications: three patients developed ischemic stroke, of these, two transient with full recovery between 24 and 48 hours postoperatively. One case remained after hospital discharge with monoplegia and dyslalia. One patient had peripheral vascular complications at the site of arterial cannulation with thrombosis, which required embolectomy and raffia with a bovine pericardial patch at the second day after surgery. These complications occurred only in cases of aortic valve replacement in patients with severe stenosis and calcification of annulus and leaflets.

One patient underwent reoperation for mitral stenosis, pulmonary hemorrhage on the fourth postoperative day, after discharge from the ICU and was managed, again in the ICU, with mechanical ventilation. Another patient had pulmonary hemorrhage on discharge from the operating room, probably secondary to complications of selective cannulation, which occurred at 3rd postoperative day. Five (4.8%) patients underwent reoperation for bleeding, all through smaller incisions, only with the help of videoendoscopy.

Five patients, all of the group GcCPB, died (4.8% or 5/105). A patient with chronic renal failure on dialysis, recent embolic stroke and diagnosis of mitral valve endocarditis, underwent urgent valve replacement and death occurred in the immediate postoperative period, for excessive bleeding, consumptive coagulopathy and irreversible cardiogenic shock. A second patient had mitral-aortic valve and mitral regurgitation, receiving double valve replacement and tricuspid valve surgery, but died on the fifth day postoperatively, for progressive and refractory cardiogenic shock. The third patient with prior prosthesis dysfunction underwent reoperation for mitral valve, had excessive bleeding, even during surgery when was diagnosed with atrioventricular groove rupture, and death, despite the attempt to correct the complication. Three patients with severe aortic stenosis and very calcified presented aortic dissection and all underwent replacement of the ascending aorta. Two patients died, due to mixed shock and bleeding, one on day 1 and the second on the 5th postoperative day. Three of these cases were converted to median sternotomy for correction of postoperative complications accounted for 2.9% of cases from GcCPB.

Ninety-three of 105 operated patients (88.6%) had complications that could alter their postoperative course and obtained 122.8 ± 8.2 4 min of CPB and 76.7 ± 35.6 min of aortic clamping, 97.8% (91/93) were extubated in the operating room. The average number of days in the intensive care unit and total hospitalization days were, respectively: 1.8 ± 0.9 days and 3.6 ± 1.3 days. All data relating patients with and without complications, are described in Table 5.

DISCUSSION

The endoscopic visualization of the pleural cavity is relatively an old technique. Earlier this century, Jacobaeus performed the first thoracoscopy inserting a cystoscope into the pleural cavity [17]. Several operations were devised by the author through thoracoscopy, and the operation known by his name, used to treat tuberculosis. The first considered minimally invasive cardiac procedures came with coronary artery bypass surgery without CPB, since when neutralizing the allegedly deleterious effects of extracorporeal perfusion, it would minimize the peroperative complications. Ankeny [18] and Kolessov [19] and Buffolo et al. [20-22], in Brazil, presented their reports in international proceedings. Lobo Filho et al. [23] in 1996 showed 97% of CABG in the last phase of his report.

The concept of minimally invasive minimal incision surgery in the heart has also occurred in the mid nineties. In the beginning, were introduced the smaller incisions to access the mitral and aortic valves and coronary arteries, such as upper or lower hemisternotomies with transection of the sternum and the lateral thoracotomy [24,25], or even left thoracotomy for revascularization of single anterior descending artery, and right thoracotomy to access the mitral valve or the right coronary artery. The right anterolateral thoracotomy had been used in the past with preference in mitral disease, but was discontinued from the best results with thoracotomy or median sternotomy [26-28].

Except for CABG, cardiac surgery with minimal incisions, especially in the aortic valve, was once considered an impediment, given the high mortality rate when compared to conventional surgery. Bridgewater et al. [29] showed 43% mortality in minimally invasive surgery compared to 7% in the conventional surgery to treat aortic valve. Even when other centers showed more encouraging results, it still does not attract the attention of cardiac surgeons in the world [30].

Also in recent years, using alternative approaches, it was implemented the percutaneous or transapical of aortic valve implants and endovascular devices, such as aortic endoprosthesis and rings for annular reduction for mitral valve and devices for occlusion of congenital atrioventricular defects [4-6, 8].

Currently, minimally invasive cardiac surgery has shown better results with the help of videoendoscopy, allowing even the greatest advances of robotics in medicine. In addition to the video equipment targeted for cardiac surgery, minimally invasive surgery was implemented after the inclusion of extrathoracic access and, in recent years, the so-called “port-access technology”, ie, technology for peripheral vascular access and aortic endoclamping [10.31].

Since 1995, multicenter studies are presented to demonstrate the efficacy of this new method. Galloway et al. [11] in 1999, gathered data from 121 centers, and included 1063 patients who underwent minimally invasive technique, with similar results to conventional surgery, with the advantage of less aggression, pain and blood transfusion, and hospital discharge and return to normal activities much earlier. In 2009, the same Dr. Galloway reported his data from a decade of experience with the method [2]. Also Grossi et al. [32] and Greco et al. [33] in 2002 and Mishra et al. [34] in 2005, reported highly favorable experience of video-assisted technique.

In the experiments reported, many centers using the technological sophistication of robotics demonstrated their experience and, despite the high investment, crowned the minimally invasive methods due to the low mortality, less ICU stay, and earlier hospital discharge [35,36].

In Brazil, Jatene et al., in 1997, Souto et al., in 2000 and Salerno et al., also in 2000, reported their initial experience with video-assisted surgery, but still on the periphery of the heart. Only since 2005, with the beginning of our experience [16,37,38] and the experience of Poffo et al. [39] in 2006, a new era of video-assisted cardiac surgery in our country has began, including intracardiac procedures via peripheral CPB, vacuum assist and minithoracotomy.

Our experience with VACS began in 2005 with the ligation of a coronary-pulmonary fistula by means of thoracoscopy [16]. We continued in the same year with our first case of treatment of mitral valve with a totally endoscopic procedure in a case of reoperation, in which we performed recommissurotomy [37]. Today, we present our series of 136 patients undergone minimally invasive techniques, including procedures on the aortic valve, mitral, congenital heart disease and on the periphery of the heart as in cardiac resynchronization therapy, coronary-pulmonary fistula, removal of extracardiac tumors and minimally invasive myocardial revascularization. We chose to include in discussions especially cases requiring CPB, due to the greater complexity of these procedures and greater uniformity of the measured data.

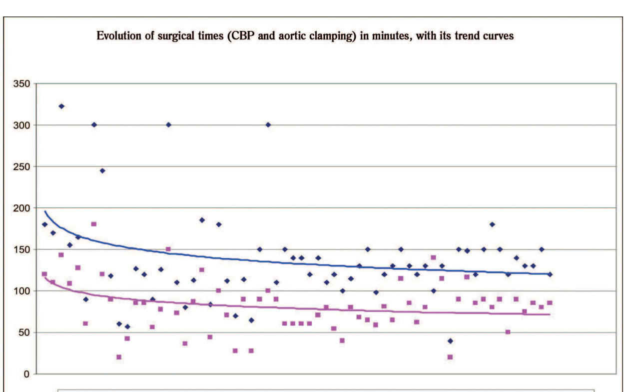

Fig. 5 - Evolution of the surgical times in minutes, with the evolution of six years of experience. CPB time, aortic clamping time and operating room time in minutes, with their trend curves (x-line with each case, following four years of experience with VACS)

The surgical steps included: CPB, aortic clamping and use of operating room are largest in video-assisted surgery than with conventional sternotomy, even so, the results have been more favorable to the minimally invasive technique. This assertion is clearly demonstrated when we assess great studies on the subject. Modi et al. [40] in 2009, showed the influence of CPB on morbidity, only in cases where the cardiopulmonary bypass time was over 180 minutes. Modi et al. [3] by means of large meta-analysis showed that, despite higher operative times, there was an improvement of postoperative results when compared to the conventional minimally invasive technique. Despite this fact, and the course of clinical experience, these times become smaller, as we have demonstrated in our series (Figure 5).

Our series showed 2.4 ± 4.5 days of hospitalization in ICU and 5.0 ± 6.8 days of hospitalization. In the group of congenital heart disease, those times were even lower, with 1.3 ± 0.5 days in ICU and 2.6 ± 0.8 days of postoperative hospitalization, numbers that demonstrate the expected result for this technique. Argenziano et al. [41] reported 20 hours of admission and 4 days of hospitalization, Modi et al. [40], six days of hospitalization, and Poffo et al. [39], 6.5 days of hospitalization.

Of the 47 patients with mitral valve disease, 39 (83.0%) underwent valve repair, this has been supported by several authors, suggesting that the mitral valve is most often achieved when using the minimally invasive cardiac surgery compared to median sternotomy. Modi et al. [40] showed 82% of mitral valve in their series and also mentioned in their reports these better results in the experience of other authors.

Also in the group of mitral valve disease, in 32 (68.1%) patients we opted to use the transseptal access to treat mitral valve and the results were better when compared to transatrial access. Best surgical times, not compromised venous drainage and repair of the septum by periods of traction without the need for atrial retractors were observed and reported in summary of study presented by our team in recent conference [42]. In surgery with sternotomy, this access has also been reviewed, offering the same benefits that we observed [43]. Navia et al. [30], in their report with minimally invasive surgery in 1996 had demonstrated the use of the transseptal access in their procedures for treatment of mitral valve.

Regarding complications occurred in our series, we found similar reports in the literature, especially in cases involving reoperation, mitral valve replacement and surgery on the aortic valve. Twelve patients had postoperative complications, among them, three cases of stroke (3/105 or

2.9%), all patients with severe aortic valve calcification and only one developed sequelae. Modi et al. [40] also reported a 2.6% of stroke in 12 years of use of the method.

Our sample reported 4.8% of deaths (5/105) in all cases using CPB, and occurred only in cases of treatment of mitral (3/47 or 6.4%) and aortic (2/39 or 5 1%) valves. In patients with congenital heart disease, complications were minimal and no deaths occurred. Regarding mortality, the registration of the "Society of Thoracic Surgeons Fall 2007 Report" reported up 6.1% mortality in cases of mitral valve replacement [44].

A complication of aortic endoclamping much reported in the literature [40,45,46] also occurred in our series. A dissection of the atrioventricular groove and rupture of the left ventricle were observed in a patient with mitral valve surgery in advance on which we used the method. Despite similar reports of occurrence also with sternotomy and aortic clamping, we decided, like many, no longer use this technique. One option in cases of reoperation, as used by our team, is the cardiac arrest on hypothermic ventricular fibrillation, performed in three patients. In the journal Circulation in 2007, Casselman et al. [47] reported the use of minimally invasive surgery for mitral valve reoperation for cardiac arrest with ventricular fibrillation, and considered the technique as first option in cases of isolated mitral reoperation.

Ninety-three patients had no complications, 88.6% of our series, and had times of postoperative hospital stay and excellent surgical evolution. Ninety-one (97.8%) patients were extubated in the operating room, remained 1.8 ± 0.9 days in the ICU and were discharged with a mean of 3.6 ± 1.3 days postoperatively. Reports similar to that found in this series were also reported by Tatooles et al. [35] Reichenspurner et al. [36], when using robotics in their surgeries.

We use a right intercostal minithoracotomy in most of our cases. In nine (23.1%) patients with aortic disease, access was performed with inverted L hemisternotomy. We chose this access in cases where the ascending aorta was very dilated and the aortic valve was very calcified, since this technique facilitates direct vision with aortic clamping and handling of the valve compromised. Other accesses like hemisternotomy in "inverted T" or "L to the left", have also been suggested by some authors, but are associated with greater trauma, minor aesthetic benefit and/or anti-pain [48-50]. In most of our aortic patients, we used the access via right anterolateral thoracotomy of 4 cm in the third intercostal space.

Septal defects are also included in the diseases of easy access for minimum procedures. The inclusion of the second cannula (jugular vein) is mandatory, because of the need to isolate the right atrium. The vena cava is closed using strings or clamped via minimal incision. Other attitudes are the same surgical procedures on the mitral valve. Our series involved 19 patients with congenital heart disease, including three cases of ventricular septal defect, with excellent surgical outcome. Eighteen patients had immediate extubation in the operating room and stayed on average 1.3 ± 0.5 days in ICU and 2.6 ± 0.8 days in hospital.

The three cases of coronary fistula were included in this study in order to demonstrate the feasibility of using laparoscopic surgery in common situations, stimulating surgeons to seek alternative approaches to conventional incisions. A survey of current literature has not reported other experiences with this technique [16.38].

In addition to the atrioventricular and aortic procedures, we used the laparoscopic in 18 cases of biventricular resynchronization and implantation of epicardial lead totally by endoscopic via. Implantation of epicardial lead via left thoracoscopy for cardiac resynchronization, is well documented in the literature [51]. Its implementation was stimulated due to the varying degrees of failure to implant via the coronary sinus. The new technique is simple and performed totally by endoscopic via and such approaches do not require thoracotomy, as in the conventional method, but three small incisions for insertion of instruments and fixation of active epicardial lead. The three-dimensional echocardiography guided these procedures [15].

Myocardial revascularization with minimal incisions was also reported in our series and coursed with good outcome and no complications. We used videothoraccoscopy or dissection of left internal thoracic artery and left anterior minithoracotomy for coronary implantation. Several authors have used this technique including Brazil [28,52], but the greatest advances in minimally invasive CABG have been shown today. Surgical procedures using robotics have allowed for multivessel coronary revascularization, in a totally endoscopic manner [53,54].

Today, increasingly, the world uses minimally invasive surgery for treatment of heart disease, but its expansion and ultimate consecration will depend on the greater ability of surgeons and a multidisciplinary team [2,3,40]. The future is even more promising because, as already happens in some centers, the smaller incisions will be replaced by totally endoscopic procedures [53,54].

CONCLUSION

The results in this series are comparable to the literature and confirm the method as an alternative to the conventional technique. The search for better cosmetic results, reduced postoperative discomfort observed in the large thoracotomy and rapid postoperative recovery are the major goals of the technique, coupled with low complication rates obviously already conquered with conventional surgery.

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