ORIGINAL ARTICLE

Is Minimally Invasive Mitral Valve Surgery Possible in Complex Patients?

¿La Cirugía Miniinvasiva de la Válvula Mitral, es posible en Pacientes Complejos?

GERMÁN A. FORTUNATO, MATÍAS N. RÍOS, ROBERTO BATTELLINI, MARCELO HALAC, TORSTEN DOENST*, VADIM KOTOWICZ**

ABSTRACT

Background: Patients at high risk of preoperative morbidity and mortality, mitral valve endocarditis or prior cardiac surgery are considered "limiting" cases to undergo minimally invasive cardiac surgery.
Objectives: The aim of this study was to assess the outcome of complex patients undergoing minimally invasive surgery. The primary endpoint was post-operative mortality at 30 days and the secondary endpoint was the analysis of technical-surgical results and early postoperative complications.
Methods: The study consisted in the retrospective analysis of mitral valve surgeries performed at Hospital Italiano de Buenos Aires from January 2010 to April 2016. A total of 135 mitral valve surgeries, 63 by minimally invasive technique (46.6%) were performed. Forty-five patients (71.4%) were considered as "complex", including those with >10% STS-PROMM risk, active endocarditis, or prior cardiac surgery.
Results: Surgeries were elective in 73.3% of cases (n=33), urgent in 22.2% (n=10) and emergent in 4.4% (n=2). Percent STS-PROM and %STS-PROMM were 6.08±10.8 and 26.7±16.8, respectively. Six patients with prior cardiac surgery and 5 with endocarditis in active treatment were included. Mitral valve replacement (14 rheumatic) was performed in 62% of patients (n=28) and mitral valve repair in 38% (n=17). No deaths were registered in mitral valve repair or mediastinitis. Mortality at 30 days was 4.4% (n=2) and conversion to sternotomy was necessary in one case.
Conclusions: The observed mortality is lower than the one calculated by the risk score (%STS-PROMM 6.08±10.8 vs. 4.4). The right video-assisted minithoracotomy offered excellent exposure and interpretation of the disease. The minimally invasive surgical technique can be used in patients with prior cardiac surgery, endocarditis and/or patients with a high preoperative risk score.

Key words: Minimally invasive - Mitral valve surgery - Mitral valve repair - Video-assisted - Reoperation

RESUMEN

Introducción: Los pacientes con riesgo preoperatorio alto de morbimortalidad, endocarditis mitral y aquellos con cirugía cardíaca previa son considerados "limitantes" para ser operados por vía cirugía miniinvasiva.
Objetivos: Evaluar resultados en pacientes complejos sometidos a cirugía miniinvasiva. Primario: mortalidad posoperatoria dentro de los 30 días. Secundario: resultados técnico-quirúrgicos y complicaciones posoperatorias tempranas.
Material y métodos: Análisis retrospectivo de las cirugías mitrales realizadas en el Hospital Italiano de Buenos Aires desde enero de 2010 hasta abril de 2016. Se realizaron 135 cirugías mitrales, 63 de ellas mediante técnica miniinvasiva (46,6%). Los pacientes considerados "complejos" fueron 45 (71,4%), incluyéndose aquellos con riesgo > 10% del STS PROMM, los pacientes con endocarditis activa y/o los pacientes con cirugía cardíaca previa.
Resultados: El 73,3% (n = 33) fueron cirugías electivas, el 22,2% (n = 10) de urgencia y el 4,4% (n = 2) de emergencia. El STS PROM% y el STS PROMM% fueron de 6,08 ± 10,8 y de 26,7 ± 16,8, respectivamente. Se incluyen 6 pacientes con cirugía cardíaca previa, 5 pacientes con endocarditis en tratamiento activo. Se realizaron reemplazo valvular mitral (14 reumáticas) en el 62% (n = 28) y plástica mitral en el 38% (n = 17). No se constataron óbitos en plástica mitral ni mediastinitis. La mortalidad a los 30 días fue del 4,4% (n = 2). Hubo conversión a esternotomía en un caso.
Conclusiones: La mortalidad observada es inferior a la calculada por puntaje de riesgo (STS PROMM%: 6,08 ± 10,8 vs. 4,4). La minitoracotomía derecha videoasistida nos ofreció una excelente exposición e interpretación de la patología. La técnica de cirugía miniinvasiva puede ser utilizada en pacientes con cirugía cardíaca previa, endocarditis y/o pacientes con puntaje alto de riesgo preoperatorio.

Palabras clave: Cirugía miniinvasiva - Cirugía valvular mitral - Plástica valvular mitral - Video-asistido - Reoperación

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Abbreviations

ACC	Aortic cross-clamping	**MRA**	Mechanical respiratory assistance
COPD	Chronic obstructive pulmonary disease	**MVP**	Mitral valve repair
CPB	Cardiopulmonary bypass	**MVR**	Mitral valve replacement
ICS	Intercostal space	**PCS**	Prior cardiac surgery
IE	Infective endocarditis	**TEE**	Transesophageal echocardiography
MICS	Minimally invasive cardiac surgery	**VN**	Venting needle

INTRODUCTION

Minimally invasive mitral valve surgery by video-assisted thoracotomy was originally reported by Carpentier in 1966, (1) followed soon after by the first mitral valve replacement performed by Chitwood (2). In 1998, the Heart Center Leipzig presented the port-access system for endoluminal aortic clamping. (3) Since then, a great number of researchers have shown the feasibility of this technique in selected patients. (4, 5) Patients with high preoperative morbidity and mortality risk, mitral valve endocarditis and history of prior cardiac surgery (PCS) by median sternotomy were considered "limiting" cases for minimally invasive surgery. More than 7,000 publications are available on the minimally invasive cardiac surgery (MICS) technique and there is still no universal agreement on the access pathway.

In-hospital and 6-month mortality for infective endocarditis (IE) is 18-27% and 22-27%, respectively. (6, 7) In 2014, Mihos et al. hypothesized that a minimally invasive surgical approach of the native mitral valve can reduce surgical trauma and post-operative complications in IE. (8)

Reoperations by sternotomy increase perioperative morbidity and mortality due to bleeding as a result of permeable graft, right ventricular or other structural injury, cardiac tamponade and mediastinitis. The difficult exposure of the mitral valve represents a challenge and hence the MICS technique was introduced as an alternative mitral valve approach.

Most reports refer that the quality of repair or replacement, as well as the safety of the procedure are not affected by a minimally invasive approach when compared with sternotomy, (9-14) with the video camera playing a fundamental role in the diagnosis.

In this work we propose certain questions to achieve defined objectives. Among the former, we consider: 1) Is it feasible to perform minimally invasive mitral valve surgery in patients with elevated risk of morbidity and mortality?; 2) Does the use of a video camera pose a problem for cardiac surgeons, taking into account that in thoracic and abdominal surgery it is already the rule?; 3) Throughout time, aortic procedures, including the ascending aorta, have been performed through a minimally invasive approach; why has this technique not been extended for the mitral valve? (12-15)

The purpose of this study was to assess the clinical outcome of complex patients undergoing minimally invasive mitral valve surgery. The primary endpoint was post-operative mortality at 30 days and the secondary endpoint was the analysis of technical-surgical results and early postoperative complications.

METHODS

A retrospective analysis was performed of the electronic clinical records of all patients undergoing MICS from January 2010 (program onset) to April 2016, which allowed 100% follow-up (median: 19 months). During this period, 135 mitral valve surgeries were performed, 63 (46.6%) by minimally invasive approach. Among these MICS patients, 45 presented with complex criteria (71.4%).

Inclusion criteria: The inclusion criteria considered patients undergoing MICS with morbidity and mortality risk >10% according to the Society of Thoracic Surgery (STS) Predicted Risk of Mortality (STS PROM), active mitral valve endocarditis, or PCS. Patients undergoing mitral valve surgery by median sternotomy and those who did not meet complex patient criteria were excluded from the study. The following independent variables were evaluated: age, sex, preoperative functional class, heart valve disease etiology, % STS PROM and STS Predicted Risk of Mortality or Major Morbidity (% PROMM) scores, preoperative status (elective, urgency, emergency), cardiopulmonary bypass (CPB) time, aortic cross-clamping (ACC) time, associated procedures, thoracic bleeding at 6, 24 and 48 hours after surgery, mechanical respiratory assistance (MRA) and length of hospital stay.

Following Mihos et al., (8) Tang et al. (16) and Holzhey et. al. (17) classifications, "complex" patients were defined as those presenting:

1) STS PROMM risk factors >10%
2) Active endocarditis: Any hospitalized patient with antibiotic therapy for this infective condition.
3) PCS: Patient previously subjected to cardiac surgery by sternotomy. These patients were previously studied with thorax computed tomography to assess adhesions.

Early complications: Need for intraoperative conversion to conventional sternotomy, cardiac arrhythmias (atrio-ventricular block, atrial fibrillation), cerebrovascular accident due to anticoagulation, in-hospital pneumonia and renal failure (creatinine +1 from baseline or requiring hemodialysis) were considered early complications.

Early postoperative mortality: This criterion was defined as death within 30 postoperative days. Mortality at one year follow-up was also evaluated.

Surgical technique: A right minithoracotomy was performed in the 4th-5th intercostal space (ICS). Two accessory ports (5mm) were used to insert the Chitwood aortic clamp (right 3rd ICS, mid-axillary line) and video camera (right 4th ICS). A Mohr atrial retractor (Geister™), long-shafted instruments for miniinvasive surgery (Geister™) and long-shafted knotters were used. A Storz™ video camera with

mechanical arm was used. Long arterial and venous cannulas (Edwards™ or Medtronic™) for CPB management were inserted through a minimal incision (3-4 mm) in the femoral artery and vein, and in all cases their position was guided and controlled by transesophageal echocardiography (TEE). A single dose of 2,000 ml Bretschneider™ cardioplegic solution was used. Deairing was achieved with a third suction instrument once the left atriotomy was closed together with an aortic venting needle (VN). Cardiopulmonary bypass was continued reducing perfusion until the CPB pump was stopped with the VN in place. Once absence of air bubbles in the heart was confirmed by TEE, CPB was briefly reinitiated to withdraw the VN and perform an extra hemostatic suture.

Statistical analysis

The information was collected in a database. Each variable was incorporated into a frequency table to analyze its distribution. Continuous variables with normal distribution were expressed as mean and standard deviation and those with non-parametric distribution as median and 25-75% interquartile range. Discrete variables were expressed as percentages.

Ethical Considerations

The study was performed following the guidelines on human subject research and legal regulations in force. As the study involved the review of clinical records and no data that could identify the patients was reported, an informed consent was waived (except in case of missing data, where a telephone call was made). The study investigators implemented the measures to protect the privacy and confidentiality of the data according to the applicable legal regulation (Personal Data Protection Law 25,326).

RESULTS

Preoperative characteristics

Patient preoperative characteristics are shown in Table1.

Elective surgeries were conducted in 73.3% (n=33) of cases, urgent surgeries (congestive heart failure, severe dyspnea or endocarditis) in 22.2% (n=10) and emergency surgeries (cardiogenic shock, acute lung edema requiring inotropic therapy and MRA) in 4.4% (n=2) of the cases. Six patients had undergone PCS by median sternotomy and 5 had preoperative active endocarditis (Figure 1). The six surgeries of the patients with PCS were: mitral valve commissurotomy, mitral valve repair (MVP), mitral valve replacement (MVR), combination surgery of MVR plus coronary artery bypass grafting, Bentall de Bono procedure (this was the 5th reoperation after multiple aortic surgeries) and one case of Bentall de Bono surgery history plus active endocarditis.

Percent STS PROM and %STS PROMM were 6.08±10.8 and 26.7±16.8, respectively.

The results of valve etiology with their respective percentages shown in Figure 2 indicate that degenerative/myxoid valve disease was the main cause of preoperative disease, followed by rheumatic valve disease, a prevalent etiology in our country.

Table 1. Preoperative characteristics of patients undergoing minimally invasive surgery

Variable	Mean±SD or nº (%)
Patients	45 (100)
Age, years	68±14.7
Age, median	71
Female gender	32 (71.1)
NYHA	2.4±0.9
% STS PROM	6.08±10.8
% STS PROMM	26.7±16.8
Prior cardiac surgery	6
Endocarditis	5

SD: Standard deviation. NYHA: New York Heart Association.

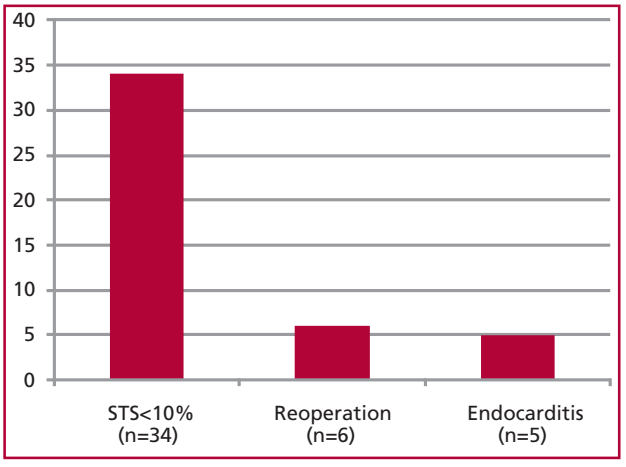

Fig. 1. Classification of "complex" groups.

Surgical and postoperative characteristics

Associated procedures were: Maze (n=5), removal of atrial thrombus (n=1) and patent foramen ovale closure (n=1). Mitral valve surgeries were: MVR [n=28 (62%), 19 with biological and 9 with mechanical prosthesis] and MVP [n=17 (38%), 5 with neochord and 2 without neochord]. Intraoperative and postoperative outcomes are described in Table 2, and the different techniques are shown in Figure 3.

Mean hospital stay was 16.5±14.8 days.

Complications and mortality

Only one patient receiving MVR required intraoperative conversion to median sternotomy due to bleeding at the level of the atrioventricular sulcus. No deaths were registered in MVP and no mediastinitis or aortic root bleeding was recorded.

Mortality: The first case was a 76-year old woman undergoing MVR and conversion to sternotomy for mitral annulus decalcification, who died on the 7th post-operative day due to multiple organ failure. The second case was an 82-year old man in active treat-

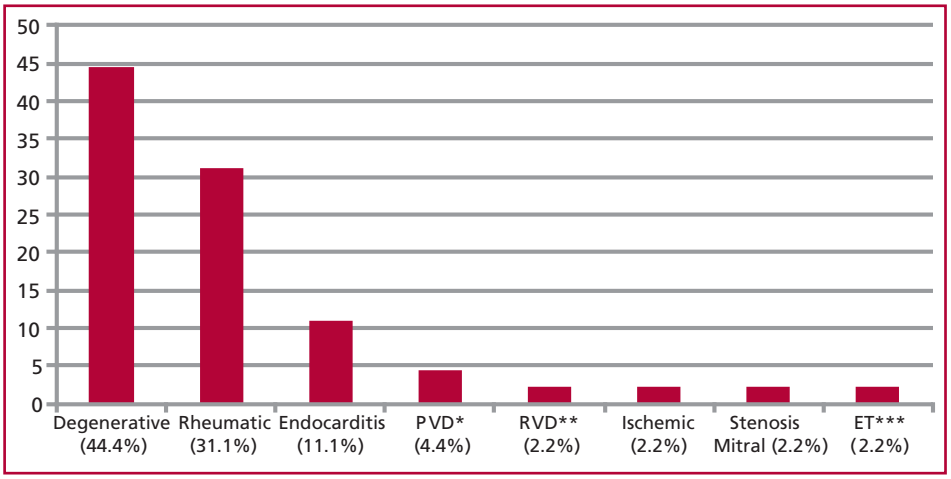

Fig. 2. Preoperative diseases. PVD: Prosthetic valve dysfunction. RVD: Repaired mitral valve dysfunction; ET: Valve lesion after endocarditis treatment.

Table 2. Intraoperative and postoperative outcomes in patients undergoing minimally invasive surgery

Variable	Mean±SD (range) or nº (%)
CPB time, min	191.8±63.9 (121-350)
Cross-clamping time, min	115.8±63.9 (87-182)
Mitral valve repair	17 (38)
Mitral valve replacement	28 (62)
Biological prosthesis	19 (42)
Mechanical prosthesis	9 (20)
Intraoperative conversion	1
Postoperative bleeding, ml	
6 hours	211.2
24 hours	413
48 hours	529.2
Length of hospital stay, days	16.5±14.8 (5-70)

SD: Standard deviation. CPB: Cardiopulmonary bypass

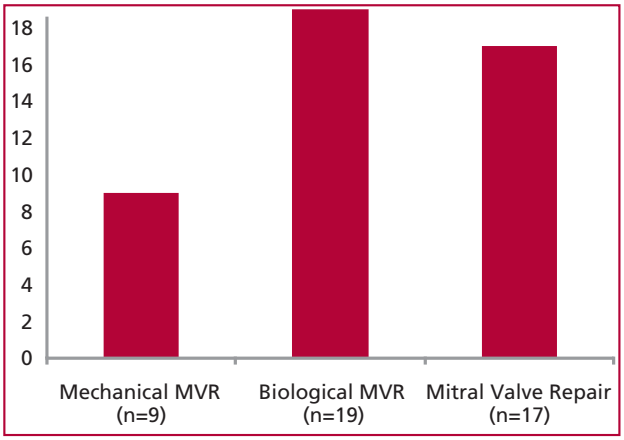

Fig. 3. Proportion of surgical techniques used.

ment for endocarditis and prior history of combination surgery (coronary artery bypass grafting+MVR) who underwent s second MVR. He died on the 21st postoperative day due to anticoagulation accident (subdural and brainstem hematoma).

Thirty-day mortality was 4.4% (n=2) and mortality at one year 8.8% (n=4). One death occurred on the 60th day after surgery, following a cerebrovascular accident due to anticoagulation and another on the 80th day after in-hospital pneumonia.

Postoperative complications within the first 30 days after surgery are summarized in Table 3.

DISCUSSION

The definition of "complex patient" is a controversial subject in the literature, probably due to the availability of diverse risk predictors (EuroSCORE II and STS score) and their lack of discrimination of the upper limits of surgical risk. Due to the absence of a precise definition of complexity by the EuroSCORE II or the STS score, we adopted the definition of Mihos et al., (8) which included IE, chronic obstructive pulmonary disease (COPD) (40.9%) and reoperations (18.1%), that of Tang et al. (15) considering patients with chronic renal failure and functional class IV dyspnea (NYHA) (43%), reoperations (37.7%), IE (17.7%) and EPOC (22.2%) and the one by Holzhey et al. (17) that incorporated patients >70 years old and reoperations (14.7%), EPOC (8.6%), IE (4.9%) and left ventricular ejection fraction <30% (4.9%) (18)

It is argued that femoral artery cannulation could generate increased risk of embolic stroke in case of peripheral arteriopathy due to retroperfusion. (19) Our patients were previously evaluated with femoral ar-

Table 3. Postoperative complications of patients undergoing minimally invasive surgery

Variable	n (%)
Atrial fibrillation	8 (17.7)
AV block	4 (8.8)
Acute renal failure	3 (6.6)
CNS hemorrhage for AC	3 (6.6)
Reexploration for bleeding	1 (2.2)

AV: Atrioventricular CNS: Central nervous system. AC: Anticoagulantion

tery Doppler echocardiography and occlusive vascular disease was ruled out, as evidenced by the absence of this complication.

The right minithoracotomy approach may be routinely performed, with favorable outcomes when the perfusion and cross-clamping strategies are carefully selected. It is essential to carry out deairing as previously explained. Thus, the risk of air microembolism and aortic bleeding are not greater than those with conventional surgery. (20) No air thromboembolism occurred, in agreement with Misfeld's series. (21)

Patients prefer minimally invasive procedures when this is suggested. Why has it not prospered? Could it be that today's surgeons do not wish to adopt MICS techniques because they are presumably more complex? An argument against minimally invasive mitral valve surgery is that the combination of minimally invasive approach with the use of video camera and long-shafted instruments can be more demanding to teach, constituting a surgical subspecialty. There are currently few systematized training programs similar to those for percutaneous valve implantation. Although there are fellowship programs in MICS (Leipzig and Berlin), there is no structured "proctorization" for this surgery. In addition, the higher CPB and cross-clamping times generate doubts among surgeons.

Throughout the years, the MICS technique has shown evidence of low short- and long-term mortality and stroke rates. (8, 9) It has been associated with decreased postoperative bleeding, transfusions, MRA time, hospital stay, lower postoperative pain and earlier work return. (22) However, MICS should perhaps be limited to specialized and trained centers in the surgical technique and perioperative management. If consistent results of low mortality and reoperation rates and high rate of repair were provided, MICS could become the first choice technique. Our field will not develop if surgeons continue to be skeptical and limit growth, as history has demonstrated with other surgical innovations. Based on the current developments in the cardiovascular field, one should ask: Would we act according to the evidence, even if we had it? (23)

Finally, we adhere to Joseph E. Bavaria in his 2017 Presidential address: "The thin line between providing treatments of quality and embracing innovations can sometimes make us, cardiac surgeons, feel we are trapped between conflicting goals. They may collide with each other, which is a challenge we must sort out." (24)

CONCLUSIONS

Video-assisted right minithoracotomy provided an excellent exposure and interpretation of the disease, minimizing the need for surgical dissection as well as morbidity and mortality. The MICS technique could be used in patients with PCC, IE and/or patients with high preoperative risk score when the right hemithorax was free from adhesions.

Twenty-four hour-bleeding was scarce (211-413 ml) with only one case which required reexploration for postoperative bleeding. No embolic complications were encountered. Mortality in this series was below the one estimated by the previous risk score calculation (%STS PROM 6.08±10.8 vs.4.4). Postoperative complications were also low.

The potential benefits of MICS, the low incidence of bleeding, early mobilization and cosmetic results may be only weak factors promoting the adoption of this technique. We believe that today's development is supported by factors not based on evidence, as the increased demand of patients and referral doctors, as well as the personal need of belonging to a highly specialized group of experts.

In conclusion, our disposition to follow evidences and guidelines could be substantially influenced by confounding non-scientific factors (procedural complexity, competition with other centers or disciplines), and last but not least, by patient demand. In the future, same as minimally invasive aortic surgery tries to compete with transcatheter aortic valve implantation (TAVI), minimally invasive mitral valve surgery is in better conditions to compete against transcatheter mitral valve repair (TMVR), as percutaneous repair of degenerative disease is very inferior to the Mohr type technique by MICS.

We finally reaffirm our belief that the development of an interdisciplinary team in heart valve diseases (Mitral Heart Team) is essential for decision-making and surgical strategies.

Conflicts of interest

None declared.
(See authors' conflicts of interest forms on the website/ Supplementary material)

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Royalties: Funds are coming in to you or your institution due to your patent

ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Roberto
2. Surname (Last Name): Battellini
3. Date: 20-July-2017

4. Are you the corresponding author? ☐ Yes ☑ No

Corresponding Author's Name: Germán Fortunato

5. Manuscript Title: ¿La cirugía miniinvasiva de la válvula mitral, es posible en pacientes complejos?

6. Manuscript Identifying Number (if you know it)

Section 2. The Work Under Consideration for Publication

Did you or your institution **at any time** receive payment or services from a third party (government, commercial, private foundation, etc.) for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.)?

Are there any relevant conflicts of interest? ☐ Yes ☑ No

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Are there any relevant conflicts of interest? ☐ Yes ☑ No

Section 4. Intellectual Property -- Patents & Copyrights

Do you have any patents, whether planned, pending or issued, broadly relevant to the work? ☐ Yes ☑ No

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Section 5. Relationships not covered above

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Section 6. Disclosure Statement

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Dr. Battellini has nothing to disclose.

Evaluation and Feedback

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ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Vadim
2. Surname (Last Name): Kotowicz
3. Date: 20-July-2017

4. Are you the corresponding author? ☐ Yes ☑ No

Corresponding Author's Name: Germán Fortunato

5. Manuscript Title: ¿La cirugía miniinvasiva de la válvula mitral es posible en pacientes complejos?

6. Manuscript Identifying Number (if you know it):

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Are there any relevant conflicts of interest? ☐ Yes ☑ No

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Are there any relevant conflicts of interest? ☑ Yes ☐ No

If yes, please fill out the appropriate information below.

Name of Entity	Grant?	Personal Fees?	Non-Financial Support?	Other?	Comments
MEDTRONIC	☐	☐	☐	☑	

Section 4. Intellectual Property -- Patents & Copyrights

Do you have any patents, whether planned, pending or issued, broadly relevant to the work? ☐ Yes ☑ No

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Dr. Kotowicz reports other from MEDTRONIC, outside the submitted work; .

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ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Torsten
2. Surname (Last Name): Doenst
3. Date: 20-July-2017

4. Are you the corresponding author? ☐ Yes ☑ No

Corresponding Author's Name: Germán Fortunato

5. Manuscript Title: ¿La cirugía miniinvasiva de la válvula mitral, es posible en pacientes complejos?

6. Manuscript Identifying Number (if you know it):

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Are there any relevant conflicts of interest? ☐ Yes ☑ No

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Are there any relevant conflicts of interest? ☐ Yes ☑ No

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Dr. Doenst has nothing to disclose.

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ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Germán
2. Surname (Last Name): Fortunato
3. Date: 20-July-2017

4. Are you the corresponding author? [✓] Yes [ ] No

5. Manuscript Title
¿La cirugía miniinvasiva de la válvula mitral, es posible en pacientes complejos?

6. Manuscript Identifying Number (if you know it)

Section 2. The Work Under Consideration for Publication

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Are there any relevant conflicts of interest? [ ] Yes [✓] No

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Dr. Fortunato has nothing to disclose.

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ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Marcelo
2. Surname (Last Name): Halac
3. Date: 20-July-2017

4. Are you the corresponding author? ☐ Yes ☑ No

Corresponding Author's Name: Germán Fortunato

5. Manuscript Title: ¿La cirugía miniinvasiva de la válvula mitral, es posible en pacientes complejos?

6. Manuscript Identifying Number (if you know it)

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Are there any relevant conflicts of interest? ☐ Yes ☑ No

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Dr. Halac has nothing to disclose.

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ICMJE Form for Disclosure of Potential Conflicts of Interest

Section 1. Identifying Information

1. Given Name (First Name): Matías
2. Surname (Last Name): Ríos
3. Date: 20-July-2017

4. Are you the corresponding author? ☐ Yes ☑ No

Corresponding Author's Name: Germán Fortunato

5. Manuscript Title: ¿La cirugía miniinvasiva de la válvula mitral, es posible en pacientes complejos?

6. Manuscript Identifying Number (if you know it)

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Are there any relevant conflicts of interest? ☐ Yes ☑ No

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Are there any relevant conflicts of interest? ☐ Yes ☑ No

Section 4. Intellectual Property -- Patents & Copyrights

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Dr. Ríos has nothing to disclose.

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