Kardiologia Inwazyjna nr 3 (15), ROK 2020

Surgical ablation for atrial fibrillation in minimally invasive mitral valve surgery. Insight from single center registry

Chirurgiczna ablacja migotania przedsionków podczas minimalnie inwazyjnej operacji zastawki mitralnej

Michał Pasierski[1], Mariusz Kowalewski[1–3], Kacper Wiszniewski[1], Jakub Staromłyński[1], Wojciech Sarnowski[1], Radosław Smoczyński[1], Anna Witkowska[1], Maciej Bartczak[1], Mariusz Kujawski[1], Dominik Drobiński[1], Waldemar Wierzba[4], Piotr Suwalski[1]

[1]Department of Cardiac Surgery, Central Clinical Hospital of the Ministry of Interior and Administration, Centre of Postgraduate Medical Education, Warsaw, Poland

[2]Thoracic Research Centre, Innovative Medical Forum, Bydgoszcz, Poland

[3]Cardio-Thoracic Surgery Department, Heart and Vascular Centre, Maastricht University Medical Centre, Maastricht, the Netherlands

[4]Satellite Campus in Warsaw, University of Humanities and Economics in Łódź, Warsaw, Poland

ABSTRACT

Introduction: Minimally invasive mitral valve surgery (MIMVS) has become widely accepted alternative to standard sternotomy approach for the treatment of complex mitral valve (MV) disease. Surgical ablation for atrial fibrillation (AF) performed at the time of other valvular- or non-valvular cardiac procedures is a mainstay of therapy; yet there exist only sparse data regarding its impact on long-term survival and particularly in the setting of MIMVS. Current investigation aimed to evaluate safety profile and long-term survival in patients undergoing MIMVS with concomitant surgical ablation for AF.

Material and methods: Between 2011 and 2018, 390 patients underwent minimally invasive mitral valve or mitral and tricuspid valve surgery. Right mini-thoracotomy was performed through a 4.0 to 6.0-cm skin incision in the fourth or fifth intercostal space depending on preoperative imaging; from 2015 forward, 3.5 to 4.0-cm periareolar access was adopted. Total of 232 patients presented with baseline AF (55.6% men, mean age 66.7 ± 9.5). Cox proportional hazards models were used for computations.

Results: Median follow-up was 3.3 years (interquartile range, IQR 1.3–4.9). Of included patients, 152 (65.5%) underwent surgical ablation. Patients in this group were younger (mean age 65.4 vs 69.2) than in control group but were at higher baseline surgical risk (EuroSCORE 2.21 vs 1.72). Mitral regurgitation was present in 148 (97.0%), MV stenosis in 37 (24.3%); additional tricuspid regurgitation in 69 (45.4%). Mitral valve repair was preferred approach that ensued in 115 (75.7%) cases, followed by MV replacement in 37 (24.3%); the polytetrafluoroethylene loops and annuloplasty rings were used in all MV repair cases. Median duration of intensive care unit stay was 3.8 [IQR: 2.0–5.9] days. The median cardiopulmonary bypass and aortic cross-clamp time was 165.0 [IQR: 130.0–200.0] minutes and 83.5 (60.3–110.0) minutes respectively. Overall 30-day mortality was estimated at 3.4%. Long-term survival was estimated at 95%.

Conclusions: Concomitant surgical ablation for atrial fibrillation in patients undergoing minimally invasive mitral valve procedures is safe and feasible. Further studies are needed to access its influence on remote survival.

Key words: minimally invasive surgery, mitral valve, atrial fibrillation, surgical ablation, mini-thoracotomy

Kardiol. Inwazyjna 2020, 15 (2), 136–147

STRESZCZENIE

Wstęp: Małoinwazyjna operacja zastawki mitralnej (MIMVS) stała się powszechnie akceptowaną alternatywą dla standardowej sternotomii w leczeniu wady zastawki mitralnej (MV). Chirurgiczna ablacja migotania przedsionków (AF) wykonywana w czasie innych zabiegów zastawkowych lub niezastawkowych serca jest uznaną formą terapii; jednak istnieją tylko nieliczne dane dotyczące jej wpływu na odległe rokowanie, w szczególności w kontekście MIMVS. Obecne badanie miało na celu ocenę profilu bezpieczeństwa i odległego przeżycia u pacjentów poddawanych MIMVS z towarzyszącą chirurgiczną ablacją AF.
Materiał i metody: Między 2011 a 2018 rokiem 390 pacjentów przebyło małoinwazyjną operację zastawki mitralnej lub zastawki dwudzielnej i trójdzielnej. Wykonano minitorakotomię prawostronną z nacięcia skóry 4,0 do 6,0 cm w czwartej lub piątej przestrzeni

międzyżebrowej w zależności od wyniku obrazowania przedoperacyjnego. Od 2015 roku przyjęto dostęp okołobrodawkowy o długości od 3,5 do 4,0 cm. Łącznie 232 pacjentów miało wyjściowo AF (55,6% mężczyzn, średni wiek 66,7 ± 9,5 roku). Analizę wykonano z zastosowaniem modelu proporcjonalnego hazardu Coxa. **Wyniki:** Mediana czasu obserwacji wyniosła 3.3 roku (rozstęp międzykwartylowy, IQR 1,3–4,9). Spośród włączonych pacjentów 152 (65,5%) zostało poddanych ablacji chirurgicznej. Pacjenci w tej grupie byli młodsi (średni wiek 65,4 *v.* 69,2) niż w grupie kontrolnej, ale mieli większe wyjściowe ryzyko chirurgiczne (EuroSCORE 2,21 *v.* 1,72 punktów). Niedomykalność MV występowała u 148 (97,0%), zwężenie MV u 37 (24,3%); dodatkowa niedomykalność zastawki trójdzielnej u 69 (45,4%). Preferowanym podejściem była naprawa zastawki mitralnej, którą wykonano w 115 (75,7%) przypadkach, a następnie wymiana MV w 37 (24,3%). We wszystkich przypadkach naprawy MV zastosowano pierścień z politetrafluoroetylenu. Mediana czasu pobytu na oddziale intensywnej terapii wyniosła 3,8 (2,0–5,9) dni. Mediana czasu krążenia pozaustrojowego i zakleszczenia aorty wynosiła odpowiednio 165 (130–200) minut i 83,5 (60,3–110,0) minut. Całkowita śmiertelność w ciągu 30 dni wyniosła 3,4%, a przeżycie długoterminowe 90%. **Wnioski:** Jednoczesna ablacja chirurgiczna migotania przedsionków u pacjentów poddawanych małoinwazyjnym zabiegom zastawki mitralnej jest bezpieczna i wykonalna. Potrzebne są dalsze badania, aby poznać jej wpływ na długoterminowe rokowanie.

Słowa kluczowe: kardiochirurgia minimalnie inwazyjna, zastawka mitralna, migotanie przedsionków, chirurgiczna ablacja, mini-torakotomia

Kardiol. Inwazyjna 2020, 15 (2), 136–147

Introduction

Over the last 20 years, minimally invasive mitral valve surgery (MIMVS) has established itself as an alternative to conventional sternotomy approach and has increasingly been used in patients with mitral valve (MV) pathology. Rather than single approach, MIMVS refers to a collection of techniques and operation-specific technologies such as modified perfusion and visualization techniques that are dedicated towards minimizing surgical access and trauma. Several studies reported promising outcomes with MIMVS as compared to conventional surgery with less pain, shorter hospital stays, faster return to normal activities, potential cost savings and superior cosmesis [1–4].

Left untreated, atrial fibrillation (AF) increases mortality and morbidity in patients undergoing heart surgery [5, 6]. Progress in our understanding of the pathogenesis of AF and its relationship with MV pathology has led to implementation of new guidelines. Performance of surgical ablation (SA) at the time of mitral operations recently has attained a class IA recommendation in The Society of Thoracic Surgeons (STS) [7] and class IIA in The European Society of Cardiology/European Society of Cardiothoracic Surgery (ESC/EACTS) guidelines [8]. At the same time, technical advancements have resulted in novel ways of treating AF, particularly in patients with MV disease. Modified MAZE IV procedure, with radiofrequency or cryoablation as the source of energy to create left atrial lesions, have been demonstrated to reduce long-term AF rates and to improve quality of life [9–11]. Frequently those techniques are performed in a minimally invasive fashion [12].

While the MAZE procedure effectively eliminates AF in most patients, the prevalence of surgical ablation during MV surgery remains low and up to 60% of patients have their AF left untreated [13]. Concerns that hold back widespread application of SA are its safety (especially in high risk patients) due to increase in operative time and complexity of MAZE procedure and lack of survival benefit data from randomized controlled trials. As for the former, a study by Nav et al. [14] showed that MAZE procedure even with high degree of complexity does not increase operative mortality and in the long term follow-up produces reduced AF burden and notably low stroke rate. Other studies have shown that concomitant SA is protective for operative mortality even among high-risk patients [15]. As for the latter a meta-analysis of 16 trials showed very significantly higher prevalence of sinus rhythm year after surgery in SA group without difference in pacemaker implantation, although indeed, showed no difference in terms of mortality [16]. Conversely, large scale retrospective studies showed survival benefit of concomitant SA in the context of MV surgery [17, 18].

There persists however lack of data regarding influence of ablation in the setting of MIMVS surgery. The objective of the current study was to report early surgical data as well as long-term outcomes of surgical ablation for AF performed at time of minimally invasive MV, with or without concomitant tricuspid valve (TV) surgery.

Material and methods

Study population

The study involved patients undergoing heart surgery between 2011 and 2018 due to mitral or mitral and tricuspid valve disease. To be eligible for inclusion, subjects had to present with AF. Data was collected prospectively in a single-center- and all-participant registry. After completion, these were retrospectively analyzed. A primary exclusion criterion was requirement of surgical procedure expanding beyond left atrial appendage occlusion (LAAO), myectomy for hypertrophic obstructive cardiomyopathy (HOCM) and atrial septal defect (ASD) or patent foramen oval (PFO) repair concomitant to MV or MV+TV surgery (e.g. TV repair, TVr) which in turn would warrant conventional sternotomy. Both MV repairs and replacement surgeries were eligible; both MV

stenosis and regurgitation could have served as an indication. Regurgitation underlying pathologies encompassed initially rheumatic, functional, degenerative, congenital, endocarditis, calcific, ischemic and other causes of MR; to better corroborate the results as well as to follow the line of the current guidelines, these were retrospectively categorized into primary and secondary regurgitation according to pertinent definitions. No other exclusion criteria were imposed. For patients undergoing MV surgery, we considered and report three categories of variables as potentially influencing the primary endpoint: 1) baseline demographics: age, gender, EuroSCORE, diabetes, body mass, hypertension, poor mobility, pulmonary hypertension, chronic kidney disease, vascular disease, chronic lung disease, left ventricular ejection faction (LVEF), coronary artery disease, previous MI, previous percutaneous coronary intervention (PCI), CCS and NYHA class; 2) mitral valve pathology: stenosis, regurgitation, regurgitation grade and category; and 3) surgical characteristics: redo, endocarditis, cardiogenic shock, intra-aortic balloon pump (IABP), critical preoperative state, iv. inotropes/nitrates, and concomitant procedures.

Surgical technique

A standard peripheral cannulation for extracorporeal circulation (ECC) in MIMVS was advocated. Cannulation of the femoral vessels was performed through surgical access (via a 3–4 cm groin incision) using Seldinger's technique (Fig. 1). For venous cannulation, a 22–25F and 60 cm long, perforated soft cannula (VFEM Femoral Venous Cannula, Edwards Lifesciences, USA or RAP cannula, LivaNova, United Kingdom) was used. The positioning of the venous cannula with its tip in the superior vena cava was achieved under 3D transesophageal echocardiography (TEE) guidance (Fig. 2). In patients scheduled for elective add-on tricuspid valve intervention, an additional venous cannula (EOPA Medtronic, USA or OptiSite, Edwards Lifesciences, USA) was inserted into the internal jugular vein. The femoral artery was cannulated with a 16–18F OptiSite (Edwards Lifesciences, USA) cannula. Choice of the cannulas was left to the surgeons' preference. Right mini-thoracotomy was performed through a 4.0 to 6.0-cm skin incision in the fourth or fifth intercostal space depending on preoperative imaging; from 2015 forward, 3.5 to 4.0-cm periareolar access was adopted (Fig. 3–5). Two additional 1.0 cm incisions were made for the thoracoscope and the aortic clamp in the 2nd and 3rd intercostal spaces. The chest cavity was inflated with carbon dioxide at a flow rate of 1.5–2 liters per minute. In all patients, a Chitwood clamp was used for cross clamping of the aorta. Heart was arrested with either a Bretschneider or a 4:1 cold blood cardioplegia infused into the aortic

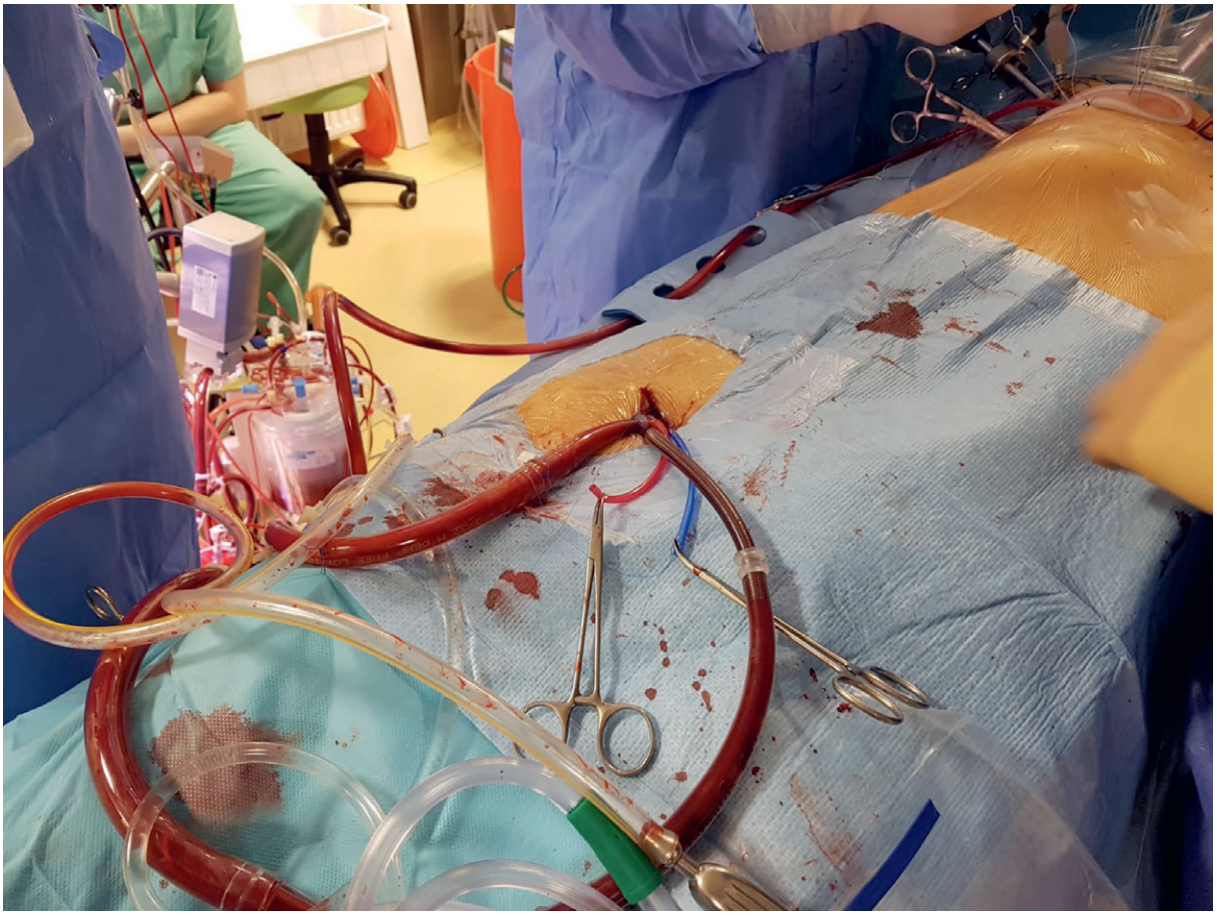

Figure 1. Cannulation for minimally invasive mitral valve surgery

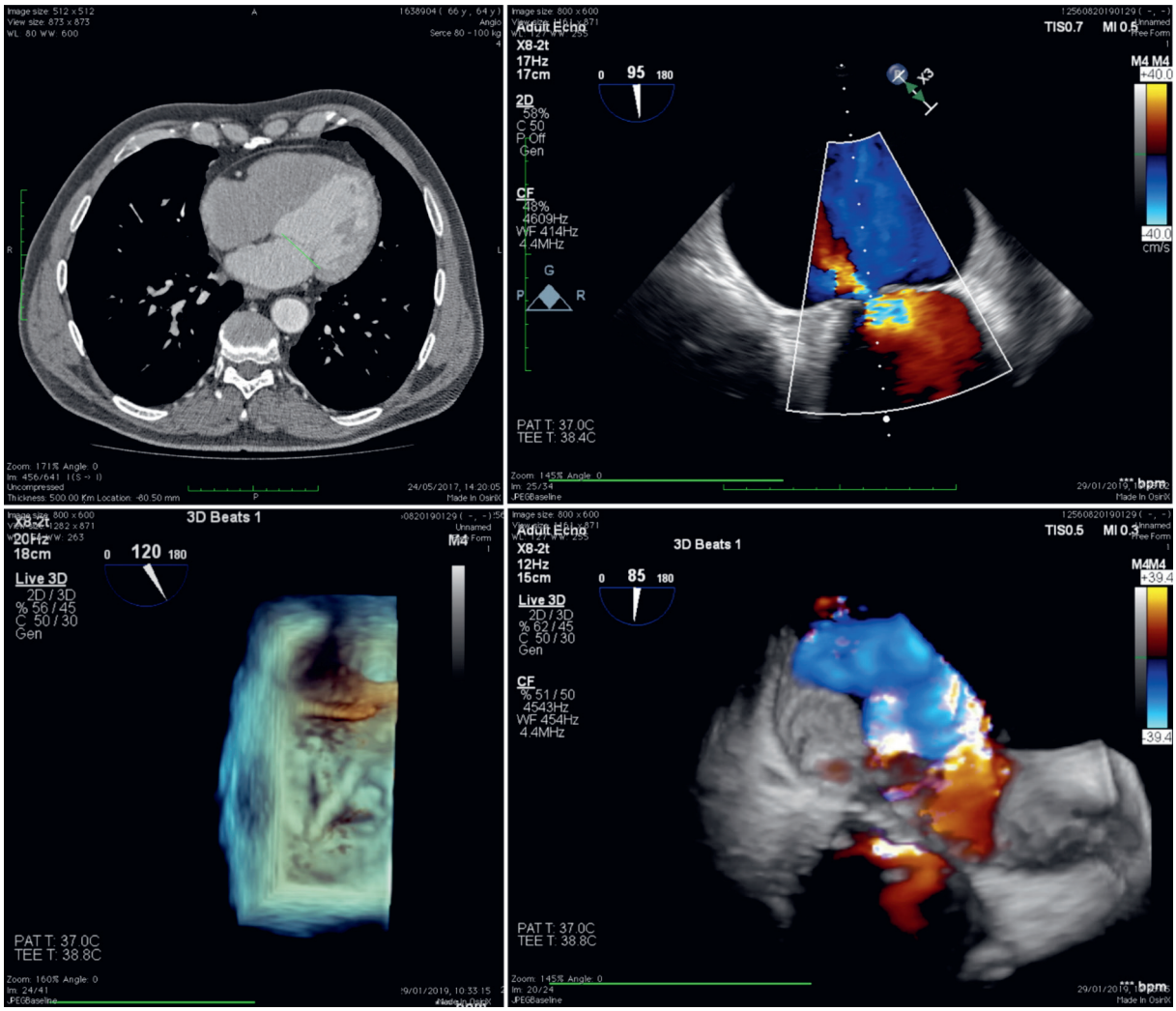

Figure 2. Preoperative 3D echo planning

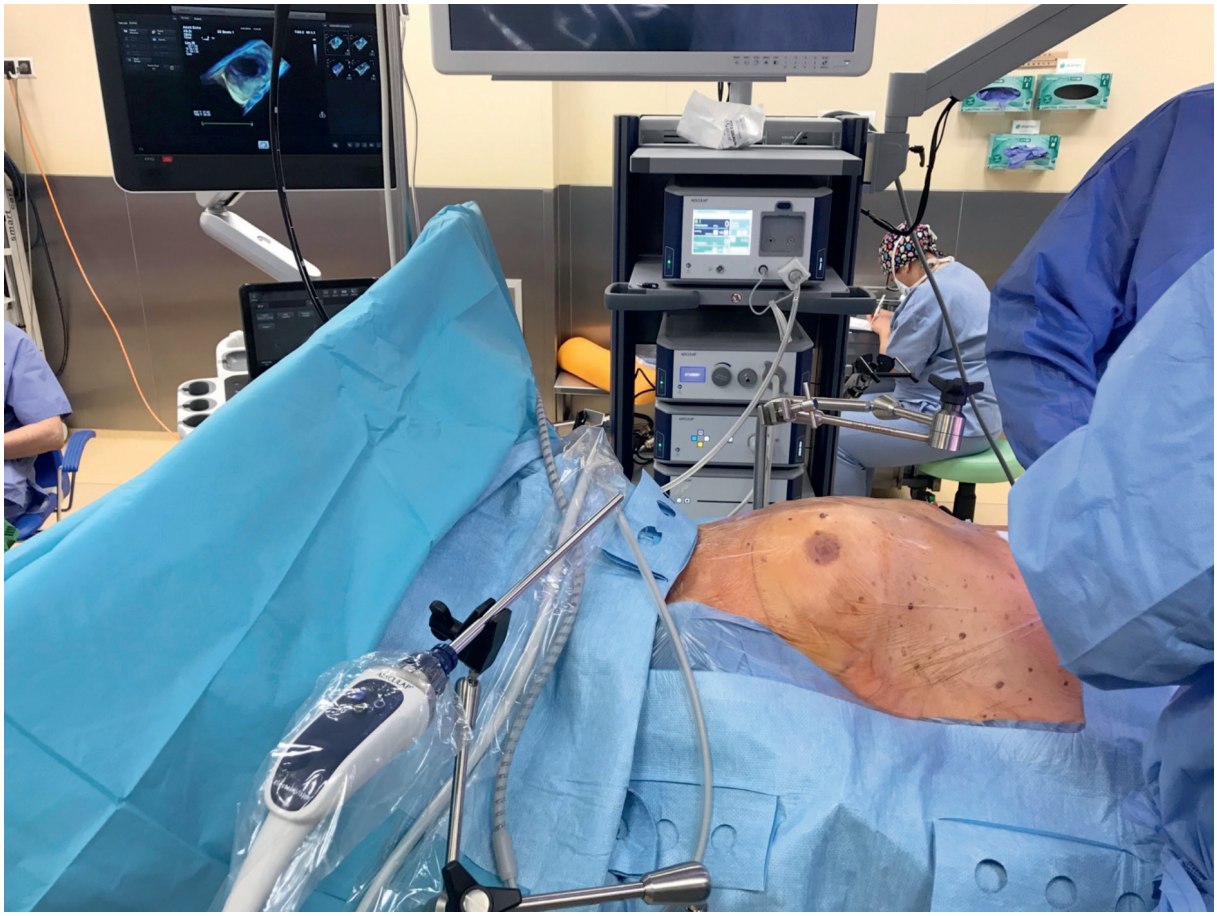

Figure 3. Surgical setup for minimally invasive mitral valve surgery

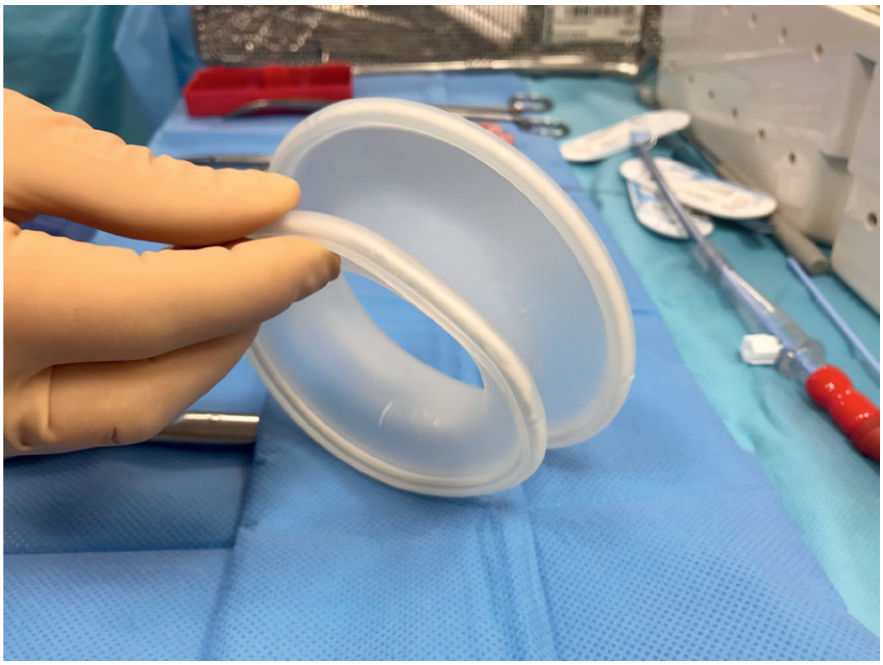

Figure 4. Soft tissue retractor

Figure 5. Minimally invasive mitral valve surgery

root under direct vision. Mitral annuloplasty was performed using semirigid mitral rings (Carpentier-Edwards Physio or Physio II Annuloplasty Ring, Edwards Lifesciences, USA or Memo 3D LivaNova, United Kingdom). In patients with mitral valve leaflet prolapse, a correction was performed using the polytetrafluoroethylene (PTFE) loop technique. In case of concomitant tricuspid valve surgery, an annuloplasty was performed on the arrested heart with a dedicated ring (MC3 Tricuspid Annuloplasty Ring, Edwards Lifesciences, USA). The acute result of the mitral and tricuspid valves' repair was confirmed in TEE. Remnant regurgitation less than or equal to 1+ was accepted.

Surgical ablation was performed according to standardized protocol. All patients underwent a modified left atrial MAZE procedure. The ablation lesions that were created included pulmonary vein isolation (PVI), connecting line in the roof of the left atrium, the line from the left inferior pulmonary vein to the mitral annulus. In those patients, ablation was performed endocardially using unipolar radiofrequency (Cardioblate, Medtronic, MN, USA) or cryothermy (Kriomedpol, Poland). Decision regarding LAAO performance was based on the anatomy of the LAA, echocardiography and left to the surgeon's discretion.

During hospital stay, amiodarone, sotalol or propaphenon were not administered in patients. Beta-blockers were prescribed during the postoperative period to maintain a minimal heart rate 50-100 beats per minute (bpm).

Definitions and endpoints

Acute kidney injury (AKI) was defined according to Kidney Disease Improving Global Outcomes (KDIGO) criteria [11]. KDIGO criteria define AKI as a 0.3 mg/dL (≥ 26.5 mol/L) serum creatinine increase from baseline within 48 hours of surgery, a 50% creatinine increase from baseline within 7 days of surgery, or a decrease in urine output below 0.5 mL/kg/hour for 6 hours. Primary endpoint assessed was 30-day and long-term survival in patients with MIMVS and ablation versus MIMVS alone. Additionally, operative times, length of intensive care unit (ICU) and hospital stay (HLoS) were reported.

Follow-up

Survival data were obtained from KROK registry [12] (available at: www.krok.csioz.gov.pl) that constitutes an ongoing, nationwide, multi-institutional registry of heart surgery procedures in Poland. The registry itself is an initiative of the Club of Polish Cardiac Surgeons in cooperation with the Polish Ministry of Health that commenced in 2006 and transfers the data concerning every cardiac surgery to the central database in the National Centre for Healthcare Information Systems at the Ministry of Health. Follow-up data regarding mortality were obtained from the National Health Fund - the nationwide, obligatory, public health insurance institution in Poland and further incorporated to the KROK registry.

Statistical analysis

Continuous, normally distributed variables were summarized as mean ± standard deviation; variables with non-normal distributions were summarized as median (interquartile range; IQR). Categorical variables were expressed as number (percentage). The ensuing statistical models were used to define the hazard ratios (HRs) and 95% confidence intervals (95% CI) of the effect size and to evaluate the safety of ablation with respect to MV surgery.

Results

During 8-year study period (2011–2018) 390 patients undergoing MIMVS surgery were identified. Among them 232 initially presented with AF. Subjects were divided into MIMVS plus ablation (152, 65.5%) and control group with MIMVS alone (80, 34.5%) (Fig. 6). All patients with paroxysmal and persistent AF were in the sinus rhythm (SR) before surgery. Median follow-up was 3.3 years (IQR 1.3–4.9). Patients in the MIMVS plus SA group were younger (65.4 vs 69.2, $P = 0.007$) but were at higher baseline surgical risk (EuroSCORE 2.21 vs 1.72, $P < 0.001$). Percentage distribution of patients across ranges of NYHA classes and LVEF was similar between groups. MV and ablation patients less often had CCS 1 score, less often had previous MI (7.2% vs 16.3%) and more often underwent PCI (6.9% vs 2.5%). Patients in MV and SA group also less often had diabetes (24.5% vs 32.5%) and more often had pulmonary hypertension (7.2% vs 1.3%). Regarding clinical characteristics at the time of procedure, MMVS and SA subjects less commonly had endocarditis (0.0% vs 7.5%; $P = 0.002$), and their surgery was less often a redo surgery (3.3% vs 10.0%, $P = 0.066$) as compared to MIMVS alone subgroup.

Primary mitral regurgitation was a dominant cause in the entire population (94.0% for primary regurgitation vs 6.0% for secondary regurgitation); and was more prevalent in the control group (97.4% in MIMVS plus SA vs 87.5% in control). There were no significant differences in grade of mitral regurgitation between subgroups. The details on operative data is further presented in Table 2.

Operative and long-term data

Significantly more patients received MV repair than MV replacement (75.0% vs 25.0%, respectively). In the subgroup analysis, there was no difference between MIMVS plus SA and controls in terms of preferred approach (24.3% vs 26.2%; $P = 0.873$). Additional tricuspid intervention was performed in 69 (45.4%) in MIMVS plus SA group and in 32 (40.0%) in the control group ($P = 0.447$). Left atrial appendage closure was significantly more prevalent in MIMVS plus SA group (18.4% vs 1.3%, $P < 0.001$).

Overall median CPB time was 165 (130–200) minutes and was no different between MIMVS plus SA and control group (165.5 vs 165.0, $P = 0.652$, respectively). Median cross clamp time was 83.5 (60.3–110.0) minutes in the whole analysis and was 22.5 minutes shorter in the MIMVS alone group (88.0 vs 65.5; $P = 0.016$).

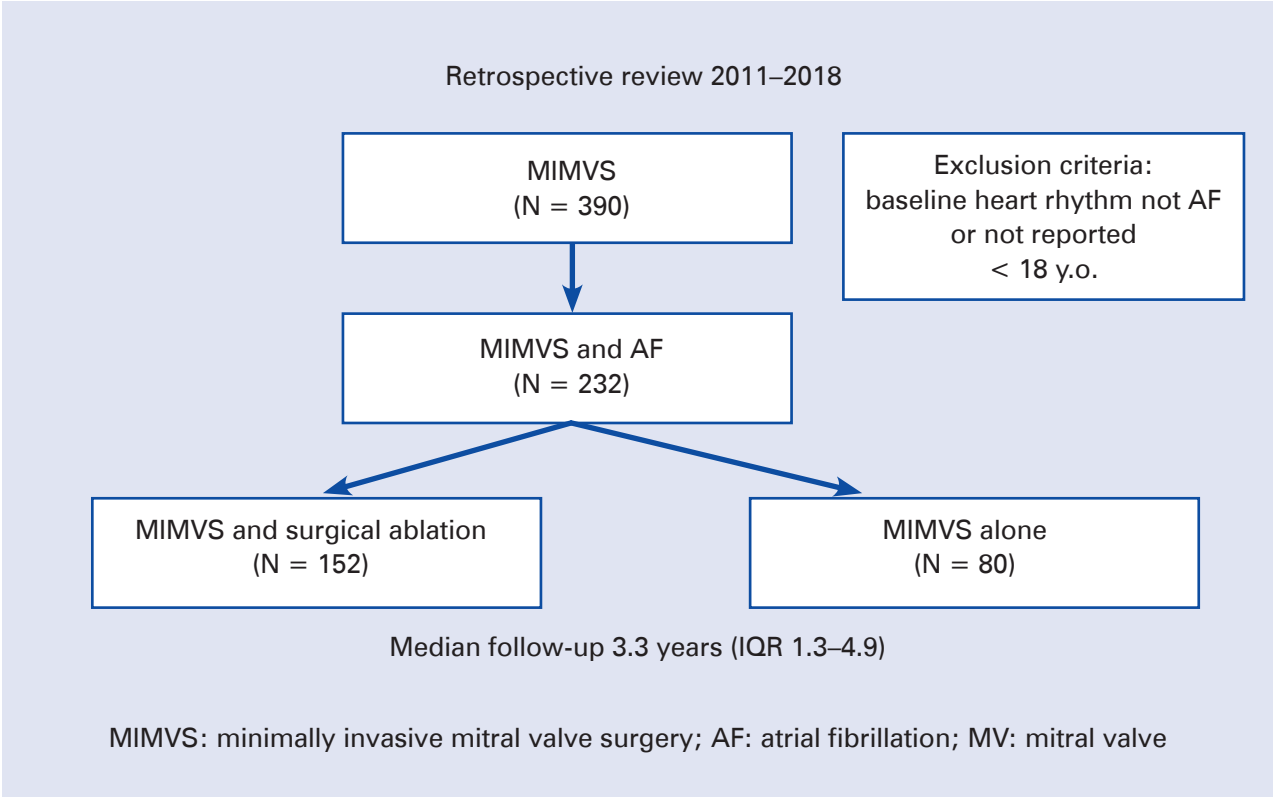

Figure 6. Flow diagram of the study cohort undergoing minimally invasive mitral valve surgery with or without concomitant surgical ablation for atrial fibrillation

Average HLoS was 19.0±17.3 days and ICU stay was 6.6 ± 10.3 days. Hospital length of stay was significantly longer in control group (16.7 ± 13.8 in MIMVS plus SA vs 23.3 ± 22.0 in controls, P = 0.019) but the duration of ICU stay did not differ (5.5 ± 8.3 vs 8.8 ± 13.9 days, P = 0.207, respectively).

There was a difference in 30-day mortality (HR 0.72, 95% CI 0.60–0.88, P < 0.001). A list of remaining in-hospital outcomes is available as Table 3. Within investigated follow-up unadjusted hazard ratio for long-term survival favored surgical ablation (HR 0.71, 95% CI 0.63–0.79, P < 0.001. Overall long-term survival was estimated at 95% for the MIMVS and ablation group (Fig. 7).

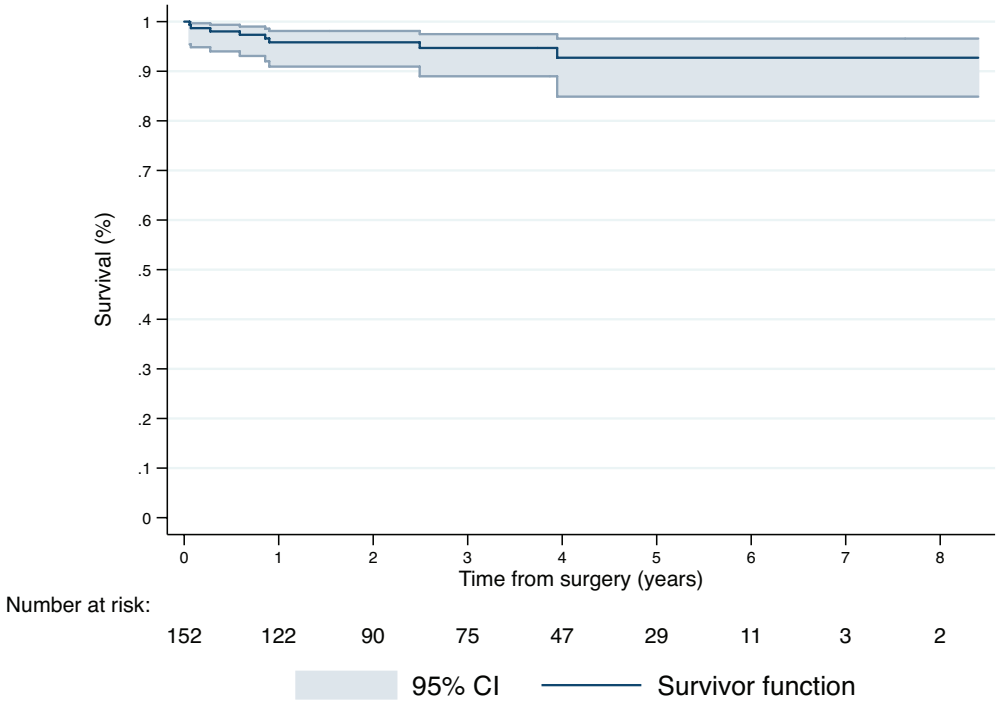

Figure 7. Long-term survival

Discussion

Minimally invasive mitral valve surgery has been established as a method of choice in patients with MV disease as it is associated with less post-operative pain, shorter duration of hospital and ICU stay and less bleeding and fewer need for transfusion [1–3]. The long-term survival and durability of the repair is comparable with standard median sternotomy approach [19] and the hospital costs are equivalent [20].

Ablation of AF during classical mitral valve surgery has a long-established safety and efficacy profile which is reflected both in American and European guidelines. Performance of surgical ablation at the time of mitral operations has attained a class IA recommendation in The Society of Thoracic Surgeons (STS) stating that surgical ablation for AF can be performed without additional risk of operative mortality or major morbidity [7], and class IIA in The European Society of Cardiology/European Society of Cardiothoracic Surgery (ESC/EACTS) guidelines [8]. Some scepticism in European guidelines can be attributed to limited evidence on influence of concomitant ablation on long-term survival especially from RCT. In the first randomised trial of 69 patients with permanent AF undergoing MV surgery with or without epicardial left atrial cryoablation 94 % of patients were in sinus rhythm after the procedure while 73.3% maintained it after 12 months' follow-up. However, the study did not report longer follow-up and was underpowered for post-operative complications [21]. In the largest, conducted to date study by Gillinow and colleagues involving 260 patients with persistent or long-standing persistent AF, the addition of surgical ablation at the time of MV surgery significantly increased the rate of freedom from AF at 1 year. However, the risk of major cardiac or cerebrovascular adverse events at 1 year did not differ between groups (HR, 0.76; 95% CI, 0.32–1.84; P = 0.55) [22]. Similarly, Cochrane library systemic review of 22 trials on ablation concomitant to cardiac surgery showed no definite differences in 30-day and long-term (> 12 months) mortality [23]. On the other hand, an analysis from KROK registry of 11,381 patients with AF who underwent MV surgery showed, after propensity matching nearly a 20% survival benefit in patients who had concomitant SA [18]. Another propensity matched study of Lee et al compared patients with preoperative AF who had an ablation to those without AF, and showed similar survival in both groups at 5 years. Additionally, the study showed higher survival in patients who had successful ablation to those with unsuccessful one [17].

Occasionally, reluctance to perform ablation may reflect concerns about prolonging cross-clamp times. In our study, cardiopulmonary bypass time was no different but cross-clamp time was 22.5 minutes longer in patients undergoing concomitant ablation. However, the ICU stay did not differ between groups which suggests that the concern of prolonging operative times is unjustified (longer ICU and HLoS times in control group may reflect the greater comorbidity burden in these patients rather than beneficial influence of ablation). A study by Ad et al showed that Cox-MAZE procedure, even with a high degree of complexity did not increase operative risk and demonstrated reduced AF burden, and resulted in remarkably low stroke rates in the long-term [14]. It should be noted that individual surgeon experience and training influences significantly the results of long-term surgical ablation for AF. Therefore, we want to highlight crucial role of education and training in increasing implementation of SA concomitant to MV surgery (which is low in Poland, according to KROK analysis at 21.5%).

Biggest concern with minimally invasive approach in ablation surgery is the fact that limited exposure might result in simplification of ablation lines and possibly conduction gaps [24]. These shortcomings were partly remedied with the introduction of alternate energy sources such as cryoablation and radiofrequency which replaced surgical incisions [25]. There have been few articles published concerning SA concomitant to MIMVS. Jiang and colleagues run an analysis of 152 patients with SA concomitant to MV surgery of which 69 were performed in minimally invasive fashion, through right minithoracotomy, and showed no difference in ablation success compared to median sternotomy approach, but faster recovery in right minithoracotomy group [26]. Marchetto et al. [24] studied the long-term efficacy of endocardial cryoablation during MIMVS. Freedom from AF was established to be at 95%, 87%, and 72% at 1, 3, and 5 years, respectively. A study by Massimiano et al. described 292 patients who underwent minimally invasive fibrillating heart surgery of which 34 had both MV surgery and AF ablation. Although the authors those not provide operative and long-term results specifically for this subgroup, the overall results were remarkable with just 1 operative mortality and sinus rhythm in 85%, and 77% of patients at 12 and 24 months follow-up respectively [27].

An argument in favour of SA during MIMVS in our study seems to be fewer post-operative neurologic complications (0.7% vs 10.0%, P = 0.002). From literature the rate of neurologic complications in minimally invasive cardiac surgery is around 2% [28, 29]. Among patients with AF the risk is even higher, therefore a very low rate of adverse neurological events in ablation group suggest that it may have acted protectively. On the other hand, an exceptionally high number of cases in no ablation group suggests that these patients may have had other comorbidities that favoured hypercoagulable state post-operatively.

What is unique in our study is that it, as one of a few, evaluates safety of SA in the setting of MIMVS. We showed that SA has a remarkable short- and long-term safety profile and should be always considered when patient with AF undergoes MIMVS. This study however should not be seen as an argument for survival benefit with ablation as it was not randomized, decision about performing ablation was left to surgeon discretion and therefore vulnerable to bias. Moreover, we did not obtain heart rhythm follow up, so it is impossible to access in how many cases AF recurred. Additional studies are necessary to establish influence on SA ablation concomitant to MV surgery on long-term survival.

Conclusions

Concomitant surgical ablation for atrial fibrillation in patients undergoing minimally invasive mitral valve procedures is safe and feasible. Further studies are needed to assess its influence on long-term survival.

Table 1. Preoperative characteristics

Variable	MIMVS + ablation (152)
Baseline characteristics	
Age years (median [IQR])	67 [61–71]
< 50	10 (6.6%)
50–70	96 (63.2%)
> 70	46 (30.3%)
Gender	
Male	79 (52.0%)
Female	73 (48.0%)
Euroscore (median [IQR])	2.21 [1.64–3.61]
< 2	59 (38.8%)
2–5	76 (50.0%)
> 5	17 (11.2%)
Diabetes	31 (20.4%)
Diet only	3 (2.0%)
Oral hypoglycemic drugs	17 (11.2%)
Insulin ± oral hypoglycemic drugs	8 (5.3%)
Smoking	35 (23.0%)
Hypertension	95 (62.5%)
Hyperlipidemia	58 (38.2%)
Poor mobility	3 (2.0%)
BMI (median [IQR])	28.1 [25.0–30.4]
Pulmonary hypertension	11 (7.2%)
Moderate (PA systolic 31–55 mm Hg)	10 (6.6%)
Severe (PA systolic > 55 mm Hg)	1 (0.7%)
Renal impairment	36 (23.7%)
Moderate (CC > 50 & < 85)	27 (17.8%)
Severe (CC < 50)	9 (5.9%)
Dialysis (regardless of CC)	0 (0.0%)

Peripheral artery disease	7 (4.6%)
Cerebrovascular disease	3 (2.0%)
History of stroke	0 (0.0%)
History of TIA	2 (1.3%)
Carotid intervention	0 (0.0%)
Chronic lung disease	7 (4.6%)
Asthma	8 (5.3%)
LVEF (%) (median [IQR])*	55 [45–61]
< 20%	0 (0.0%)
21–30%	9 (5.9%)
31–50%	57 (37.5%)
> 50%	82 (53.9%)
CAD*	
1 VD	4 (2.6%)
2 VD	1 (0.7%)
3 VD	1 (0.7%)
LM disease	1 (0.7%)
Previous MI	11 (7.2%)
> 1	1 (0.7%)
Previous PCI	16 (10.5%)
NYHA	
0	9 (5.9%)
I	49 (32.2%)
II	43 (28.3%)
III	39 (25.7%)
IV	10 (6.6%)
CCS	
0	101 (66.4%)
1	26 (17.1%)
2	15 (9.9%)
3	11 (7.2%)
4	1 (0.7%)
ACS	0 (0.0%)

*missing data
IQR: interquartile range; BMI: body mass index; PA: pulmonary artery; CC: creatinine clearance; TIA: transient ischemic attack; LVEF: left ventricle ejection fraction; CAD: coronary artery disease; VD: vessel disease; MI: myocardial infarction; PCI: percutaneous coronary intervention; NYHA: New York Heart Association; CCS: Canadian Cardiovascular Society

Table 2. Operative characteristics

Variable	MIMVS+ ablation (152)
Procedural characteristics	
Redo surgery	5 (3.3%)
Endocarditis	0 (0.0%)
Cardiogenic chock	2 (1.3%)
Critical preoperative state	1 (0.7%)
IABP	0 (0.0%)
Iv. Inotropes	2 (1.3%)
Iv. Nitrates	2 (1.3%)
Valve pathology	
Mitral regurgitation grade	
Trivial	0 (0.0%)
Mild	9 (5.9%)
Moderate	31 (20.4%)
Severe	108 (71.1%)
Mitral pathology	
Primary	148 (97.4%)
Secondary	4 (2.6%)
Mitral valve stenosis	20 (13.2%)
Surgery	
MV replacement	37 (24.3%)
MV+TV	69 (45.4%)
MV + LAAO	85 (55.9%)

IABP: intra-aortic balloon pump; iv: intravenous; MV: mitral valve; TV: tricuspid valve; LAAO: left atrial appendage occlusion

Table 3. In-hospital outcomes

Procedural complications	MIMVS + ablation (n = 152)
Early postoperative mortality	0 (0.0%)
30-day mortality	2 (1.3%)
Cardiac tamponade and/or rethoracotomy	5 (3.3%)
Periprocedural MI	1 (0.7%)
Respiratory failure	4 (2.6%)
Prolonged ICU stay (> 48 hours)	9 (5.9%)
Neurologic complications	1 (0.7%)
Multiorgan failure	2 (1.3%)
Gastrointestinal complications	2 (1.3%)
Acute kidney failure and/or dialysis	2 (1.3%)
Mediastinitis	0 (0.0%)
PPI	4 (2.6%)
ECMO	1 (0.7%)
IABP	2 (1.3%)

MI: myocardial infarction; ICU: intensive care unit; PPI: permanent pacemaker implantation; ECMO: extracorporeal membrane oxygenation; IABP: intra-aortic balloon pump

References:

1. Schmitto JD, Mokashi SA, Cohn LH. Minimally-invasive valve surgery. J Am Coll Cardiol. 2010; 56(6): 455–462, doi: 10.1016/j.jacc.2010.03.053, indexed in Pubmed: 20670754.
2. Casselman FP, Van Slycke S, Dom H, et al. Endoscopic mitral valve repair: feasible, reproducible, and durable. J Thorac Cardiovasc Surg. 2003; 125(2): 273–282, doi: 10.1067/mtc.2003.19, indexed in Pubmed: 12579095.
3. Santana O, Reyna J, Grana R, et al. Outcomes of minimally invasive valve surgery versus standard sternotomy in obese patients undergoing isolated valve surgery. Ann Thorac Surg. 2011; 91(2): 406–410, doi: 10.1016/j.athoracsur.2010.09.039, indexed in Pubmed: 21256280.
4. Javadikasgari H, Suri RM, Tappuni B, et al. Minimally invasive mitral valve repair. Heart. 2018; 104(10): 861–867, doi: 10.1136/heartjnl-2016-310774, indexed in Pubmed: 29298816.
5. Saxena A, Dinh DT, Reid CM, et al. Does preoperative atrial fibrillation portend a poorer prognosis in patients undergoing isolated aortic valve replacement? A multicentre Australian study. Can J Cardiol. 2013; 29(6): 697–703, doi: 10.1016/j.cjca.2012.08.016, indexed in Pubmed: 23142344.
6. Quader MA, McCarthy PM, Gillinov AM, et al. Does preoperative atrial fibrillation reduce survival after coronary artery bypass grafting? Ann Thorac Surg. 2004; 77(5): 1514–22; discussion 1522, doi: 10.1016/j.athoracsur.2003.09.069, indexed in Pubmed: 15111135.
7. Badhwar V, Rankin JS, Damiano RJ, et al. The Society of Thoracic Surgeons 2017 Clinical Practice Guidelines for the Surgical Treatment of Atrial Fibrillation. Ann Thorac Surg. 2017; 103(1): 329–341, doi: 10.1016/j.athoracsur.2016.10.076, indexed in Pubmed: 28007240.
8. Kirchhof P, Benussi S, Kotecha D, et al. ESC Scientific Document Group. 2016 ESC Guidelines for the management of atrial fibrillation developed in collaboration

with EACTS. Eur Heart J. 2016; 37(38): 2893–2962, doi: 10.1093/eurheartj/ehw210, indexed in Pubmed: 27567408.

9. Doukas G, Samani NJ, Alexiou C, et al. Left atrial radiofrequency ablation during mitral valve surgery for continuous atrial fibrillation: a randomized controlled trial. JAMA. 2005; 294(18): 2323–2329, doi: 10.1001/jama.294.18.2323, indexed in Pubmed: 16278360.
10. Abreu Filho CAC, Lisboa LAF, Dallan LAO, et al. Effectiveness of the maze procedure using cooled-tip radiofrequency ablation in patients with permanent atrial fibrillation and rheumatic mitral valve disease. Circulation. 2005; 112(9 Suppl): I20–I25, doi: 10.1161/CIRCULATIONAHA.104.526301, indexed in Pubmed: 16159816.
11. Cheng DCH, Ad N, Martin J, et al. Surgical ablation for atrial fibrillation in cardiac surgery: a meta-analysis and systematic review. Innovations (Phila). 2010; 5(2): 84–96, doi: 10.1097/IMI.0b013e3181d9199b, indexed in Pubmed: 22437354.
12. Pearman CM, Poon SS, Bonnett LJ, et al. Minimally Invasive Epicardial Surgical Ablation Alone Versus Hybrid Ablation for Atrial Fibrillation: A Systematic Review and Meta-Analysis. Arrhythm Electrophysiol Rev. 2017; 6(4): 202–209, doi: 10.15420/aer/2017.29.2, indexed in Pubmed: 29326836.
13. Gammie JS, Haddad M, Milford-Beland S, et al. Atrial fibrillation correction surgery: lessons from the Society of Thoracic Surgeons National Cardiac Database. Ann Thorac Surg. 2008; 85(3): 909–914, doi: 10.1016/j.athoracsur.2007.10.097, indexed in Pubmed: 18291169.
14. Ad N, Holmes SD, Massimiano PS, et al. Long-term outcome following concomitant mitral valve surgery and Cox maze procedure for atrial fibrillation. J Thorac Cardiovasc Surg. 2018; 155(3): 983–994, doi: 10.1016/j.jtcvs.2017.09.147, indexed in Pubmed: 29246544.
15. Rankin JS, He X, O'Brien SM, et al. The Society of Thoracic Surgeons risk model for operative mortality after multiple valve surgery. Ann Thorac Surg. 2013; 95(4): 1484–1490, doi: 10.1016/j.athoracsur.2012.11.077, indexed in Pubmed: 23522221.
16. Phan K, Xie A, La Meir M, et al. Surgical ablation for treatment of atrial fibrillation in cardiac surgery: a cumulative meta-analysis of randomised controlled trials. Heart. 2014; 100(9): 722–730, doi: 10.1136/heartjnl-2013-305351, indexed in Pubmed: 24650881.
17. Lee R, McCarthy PM, Wang EC, et al. Midterm survival in patients treated for atrial fibrillation: a propensity-matched comparison to patients without a history of atrial fibrillation. J Thorac Cardiovasc Surg. 2012; 143(6): 1341–51; discussion 1350, doi: 10.1016/j.jtcvs.2012.02.006, indexed in Pubmed: 22465031.
18. Suwalski P, Kowalewski M, Jasinski M, et al. Survival after surgical ablation for atrial fibrillation in mitral valve surgery: Analysis from the Polish National Registry of Cardiac Surgery Procedures (KROK). J Thorac Cardiovasc Surg. 2018.
19. Galloway AC, Schwartz CF, Ribakove GH, et al. A decade of minimally invasive mitral repair: long-term outcomes. Ann Thorac Surg. 2009; 88(4): 1180–1184, doi: 10.1016/j.athoracsur.2009.05.023, indexed in Pubmed: 19766803.
20. Atluri P, Stetson RL, Hung G, et al. Minimally invasive mitral valve surgery is associated with equivalent cost and shorter hospital stay when compared with traditional sternotomy. J Thorac Cardiovasc Surg. 2016; 151(2): 385–388, doi: 10.1016/j.jtcvs.2015.08.106, indexed in Pubmed: 26432722.
21. Blomström-Lundqvist C, Johansson B, Berglin E, et al. A randomized double-blind study of epicardial left atrial cryoablation for permanent atrial fibrillation in patients undergoing mitral valve surgery: the SWEDish Multicentre Atrial Fibrillation study (SWEDMAF). Eur Heart J. 2007; 28(23): 2902–2908, doi: 10.1093/eurheartj/ehm378, indexed in Pubmed: 17984136.
22. Gillinov AM, Gelijns AC, Parides MK. Surgical ablation of atrial fibrillation during mitral-valve surgery. N Engl J Med. 2015; 372(15): 1399–1409, doi: 10.1056/NEJMoa1500528, indexed in Pubmed: 25853744.
23. Huffman MD, Karmali KN, Berendsen MA, et al. Concomitant atrial fibrillation surgery for people undergoing cardiac surgery. Cochrane Database Syst Rev. 2016(8): CD011814, doi: 10.1002/14651858.CD011814.pub2, indexed in Pubmed: 27551927.
24. Marchetto G, Anselmino M, Rovera C, et al. Results of Cryoablation for Atrial Fibrillation Concomitant With Video-Assisted Minimally Invasive Mitral Valve Surgery. Semin Thorac Cardiovasc Surg. 2016; 28(2): 271–280, doi: 10.1053/j.semtcvs.2016.04.006, indexed in Pubmed: 28043429.
25. Edgerton ZJ, Edgerton JR. A review of current surgical treatment of patients with atrial fibrillation. Proc (Bayl Univ Med Cent). 2012; 25(3): 218–223, doi: 10.1080/08998280.2012.11928831, indexed in Pubmed: 22754118.
26. Jiang Z, Tang M, Ma N, et al. Right minithoracotomy versus conventional median sternotomy for patients undergoing mitral valve surgery and Cox-maze IV ablation with entirely bipolar radiofrequency clamp. Heart Vessels. 2018; 33(8): 901–907, doi: 10.1007/s00380-018-1126-4, indexed in Pubmed: 29396769.
27. Massimiano PS, Yanagawa B, Henry L, et al. Minimally invasive fibrillating heart surgery: a safe and effective approach for mitral valve and surgical ablation for atrial fibrillation. Ann Thorac Surg. 2013; 96(2): 520–527, doi: 10.1016/j.athoracsur.2013.04.028, indexed in Pubmed: 23773732.
28. Grossi EA, Loulmet DF, Schwartz CF, et al. Minimally invasive valve surgery with antegrade perfusion strategy is not associated with increased neurologic complications. Ann Thorac Surg. 2011; 92(4): 1346–9; discussion 1349, doi: 10.1016/j.athoracsur.2011.04.055, indexed in Pubmed: 21958781.
29. Ad N, Holmes SD, Shuman DJ, et al. Minimally invasive mitral valve surgery without aortic cross-clamping and with femoral cannulation is not associated with increased risk of stroke compared with traditional mitral valve surgery: a propensity score-matched analysis. Eur J Cardiothorac Surg. 2015; 48(6): 868–72; discussion 872, doi: 10.1093/ejcts/ezv017, indexed in Pubmed: 25646401.

Correspondence:

Mariusz Kowalewski, MD
Department of Cardiac Surgery,
Central Clinical Hospital of the Ministry of Interior and Administration, Warsaw, Poland
Wołoska 137 Str, 02-507 Warsaw, PL
phone: 0048 502269249
e-mail: kowalewskimariusz@gazeta.pl