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Partial Sternotomy as an Alternative Surgical Approach for Atrioventricular Valves and Atrial Septal Diseases

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Abstract

Introduction: Since its inception, cardiovascular surgery has posed numerous technical challenges for surgeons. In a continuous quest for enhancement, cardiovascular surgeons have sought to reduce surgical trauma through the refinement of minimally invasive techniques. Therefore, this study aims to introduce a novel approach among partial sternotomies, preserving both the manubrium and xiphoid process. Our objective is to evaluate the feasibility of this surgical technique, the stability of the sternum bone in the postoperative period, the incidence of surgical wound infection, as well as the potential for patients to resume their regular activities within a 21-day timeframe. Methods: This prospective, single-center, single-arm study was conducted to assess the safety of a surgical approach involving partial sternotomy for atrioventricular valve pathologies and septal defects. A total of 18 patients were evaluated, presenting with the following: mitral insufficiency (n = 6, 30%); mitral stenosis (n = 5, 27,7%); ostium secundum-type interatrial communication (n = 3, 16,6%); sinus venosus interatrial communication, superior vena cava (n = 2, 11,1%); and myxoma (n = 2, 11,1%). Patients underwent one of the following procedures: mitral valve replacement (n = 11, 61,1%), atrial septal defect repair (n = 5, 27,7%) or atrial myxoma resection (n = 2, 11,1%). Results: One (5, 5%) patient required conversion to full median sternotomy and there were no cases of surgical wound infection. The mean length of stay was 5.4 days. Conclusion: The results found in this study show a technically feasible procedure, with no significant increase in surgical duration, and excellent outcomes regarding the

absence of surgical site infection, sternal stability, and aesthetic considerations. Most patients resumed their usual activities within the proposed time. However, further extensive case studies and comparative analyses are required to validate these outcomes in comparison to conventional sternotomy procedures.

Keywords

Sternotomy, Cardiovascular Surgical Procedures, Minimally Invasive Surgical Procedures

1. Introduction

Cardiovascular surgery, since its inception, has encountered a series of technical challenges throughout its evolutionary process. Accessing the middle mediastinum, which contains the heart and its associated vascular structures, has been and continues to be a significant challenge inherent in cardiovascular surgery. Median sternotomy for cardiovascular surgeries was introduced by Julian *et al.* in 1957 [1]. Since its introduction, cardiovascular surgery has shown significant evolution, with immeasurable technological advancements, but the median sternotomy has remained practically unchanged.

Atrioventricular valves and interatrial (congenital) septal defects have traditionally been approached through full median sternotomy or right lateral thoracotomy. These approaches, while effective, often entail broad, highly invasive accesses, leading to greater postoperative pain, risk of mediastinitis and wound dehiscence (mainly sternal) [2] [3]. With technological advancements and the ongoing search for minimally invasive techniques, video-assisted and endoscopic procedures were developed [4] [5]. However, these methods often rely on expensive instrumentation, making their widespread adoption challenging, especially in resource-limited settings [6].

In 2013, Dumantepe *et al.* [7] created and developed an alternative minimally invasive technique with modified partial sternotomy for aortic valve replacement and atrial septal defect repair. The researchers performed 16 surgeries using this technique, including six patients undergoing aortic valve replacement, and 10 undergoing atrial septal defect repair. This technique entails a median chest incision of 5 cm in the skin, followed by a "key-lock" type sternotomy, which provides excellent exposure of the right atrium and aortic valve, receiving acceptance in several centers across developed countries.

Despite technical innovations, the present study sought to introduce a novel approach among partial sternotomies, specifically preserving both the manubrium and xiphoid process. This approach aims to preserve the stability of the rib cage, thereby expediting recovery, reducing pain to facilitate respiratory performance during the immediate postoperative period, facilitating extubation and

ambulation, and allowing safe early discharge, in addition to improving the aesthetic aspect of the operative scar [8] [9]. Several studies have demonstrated the potential benefits of partial sternotomy for reducing morbidity and improving early functional recovery when compared to full sternotomy [10] [11].

Furthermore, emerging evidence suggests that partial sternotomy provides adequate surgical exposure while mitigating the risks associated with full sternotomy, including sternal dehiscence and deep sternal wound infections [12] [13]. Recent prospective studies have reinforced the utility of this approach in improving pulmonary function and reducing overall hospital stay without compromising surgical outcomes [14] [15]. Therefore, this study aims to evaluate the feasibility of this surgical technique, the stability of the sternum bone in the postoperative period, the incidence of surgical wound infection, as well as the potential for patients to resume their regular activities within a 21-day timeframe.

2. Methods

2.1. Study Design

This is a prospective, single-center intervention study involving low surgical risk patients undergoing heart surgery for atrioventricular valve and interatrial septal diseases. The study was carried out at the Cardiac Surgery Department of the Pedro Ernesto University Hospital of the State University of Rio de Janeiro (HUPE/UERJ), from January 2021 to June 2022.

2.2. Ethical Considerations

The study protocol was approved by the Research Ethics Committee of the institution under number 42329820.0.0000.5259. All patients agreed to participate in the project by signing the informed consent form, in accordance with CNS Resolution 466/12.

2.3. Study Population

The study enrolled twenty patients of both genders presenting with conditions affecting the mitral and tricuspid valves, as well as interatrial septal diseases. These patients were selected from the Cardiac Surgery outpatient clinic of HUPE/UERJ, specifically chosen for their low risk profile for conventional surgery.

Patient recruitment of patients involved a thorough preoperative evaluation, including imaging and laboratory tests to ensure the suitability of the population for meeting the study objectives.

The following inclusion criteria were adopted: patients with mitral and tricuspid valve disease; defects of the interatrial septum; cardiac tumors adhering to the interatrial septum; patients classified as New York Heart Association functional class I (NYHA I) [3]; Society of Thoracic Surgeons risk score < 4 (STS < 4) [4].

Main exclusion criteria were coexisting heart diseases (coronary artery disease, aortic valve disease, aneurysms); patients with multiple comorbidities; thoracic

deformities; reoperation).

2.4. Investigation Procedures

All patients underwent thorough preoperative evaluation, consisting of imaging tests (echocardiogram, coronary angiography for patients over 40 years of age) and laboratory tests (complete blood count, coagulation profile, liver function tests, electrolyte levels (calcium, magnesium, potassium, and sodium), blood glucose, renal function tests, lipid profile, and screening for HIV and hepatitis B and C. Patients were identified as low risk for conventional surgery, with NYHA functional class I [3], STS risk score < 4 [4], and lacked coexisting clinical conditions predictive of medium-term mortality.

The surgical approach to atrioventricular valves and septal defects was performed through partial sternotomy. The procedures were evaluated for surgical feasibility, sternal stability in the postoperative period, incidence of surgical wound infection, and early return of the patients to their usual activities.

All patients underwent general anesthesia, invasive blood pressure monitoring, central and peripheral venous access, and bladder catheterization to monitor urinary output during the procedure. The technical feasibility evaluation, including the ability to achieve an adequate surgical field and safely visualize the necessary anatomical structures throughout the surgery, was carried out by two surgeons, through a previously prepared technical file, containing procedure data and follow-up details. Follow-up comprised regular evaluations in the immediate postoperative unit, at 7 days, and at 21 days in the cardiac surgery outpatient clinic of HUPE/UERJ.

2.5. Surgical Technique

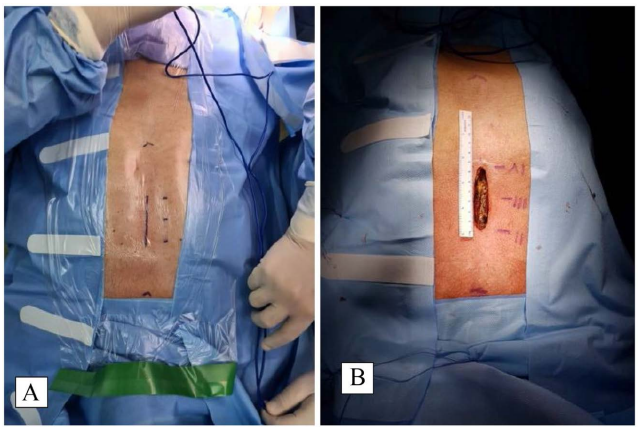

Figure 1. Surgical technique: start of the procedure. A: Skin marking indicating the intercostal spaces and incision site; B: Exposure of the anterior border of the sternum bone.

Following a midline chest incision of approximately 6 cm, dissection and exposure of the anterior sternal bone table, along with the intercostal spaces from the 2nd to the 5th on the right side, are performed (**Figure 1**). Using a circular saw, a ster-

notomy is performed in an inverted "bracket" fashion and the anterior mediastinum is accessed. Vertical pericardiotomy is then performed, revealing the cardiac structures (right atrium, superior vena cava, ascending aorta, base of the right ventricle, and inferior vena cava). Cardiopulmonary bypass is established by cannulation of the right common femoral vein, superior vena cava, and ascending aorta. Anterograde cardioplegia is administered to the aortic root (**Figure 2**). Following cavity opening and fixation of repair points, access to the targeted structures is facilitated (**Figure 3**). The sternal synthesis is performed with two steel wires, followed by subcutaneous tissue approximation in two planes with continuous suture, and skin closure with intradermal suturing (**Figure 4**).

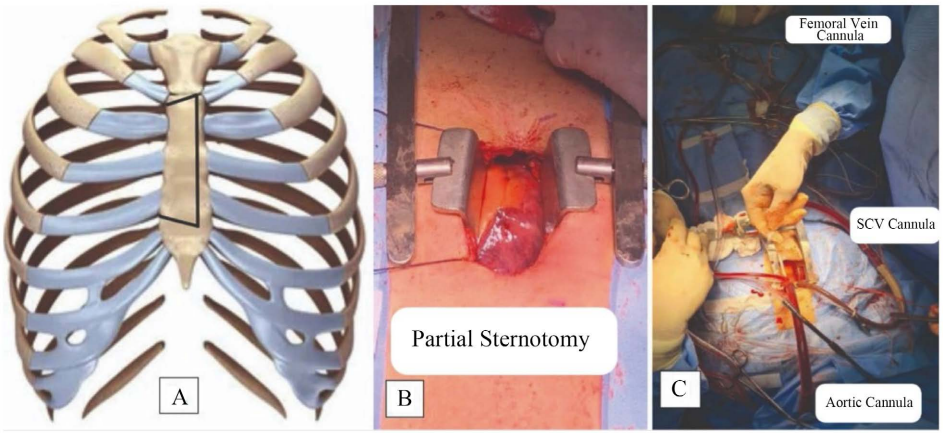

Figure 2. Surgical technique: from sternotomy to cardiopulmonary bypass. A: sternal incision configuration; B: visualization of cardiac structures following pericardiotomy; C: cannulation for cardiopulmonary bypass and infusion of cardioplegic solution.

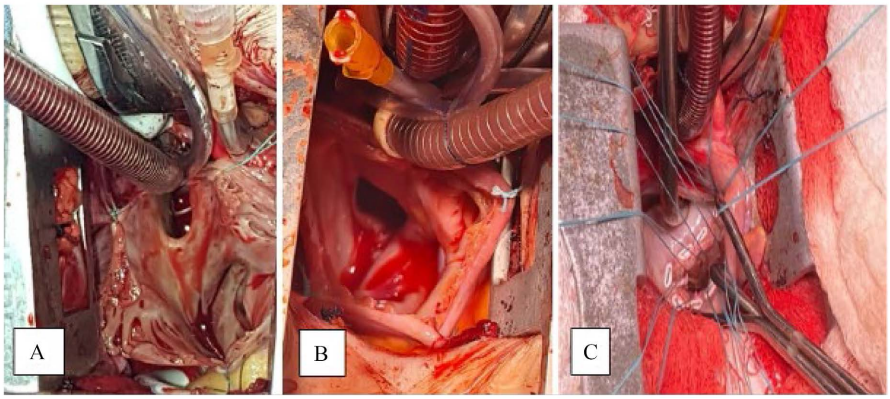

Figure 3. Surgical technique: visualization of intracardiac structures. A: exposure of the right atrium with the presence of superior vena cava atrial septal defect; B: exposure of the right atrium with the presence of ostium secundum-type atrial septal defect; C: exposure of the mitral valve.

The known risks inherent to the study were mitigated by working with an investigator with experience and skill in both valve replacement and repair surgical techniques, as well as experience in repairing septal defects. The researchers in-

volved in the study diligently identified and preemptively addressed any potential adverse events.

The main possible risks were: inadequate exposure of intracardiac structures leading to conversion to conventional surgery; aortic dissection, rupture, and aneurysm; malposition of valve prosthesis; emergency cardiac surgery; non-structural valve dysfunction; paravalvular or central leaks; valve structural deterioration; incomplete repair of septal defects; cardiac arrhythmias; vascular complication; access site injury; hemorrhage; hematoma; surgical site infection; bacterial endocarditis; pericarditis; pericardial effusion; pleural effusion.

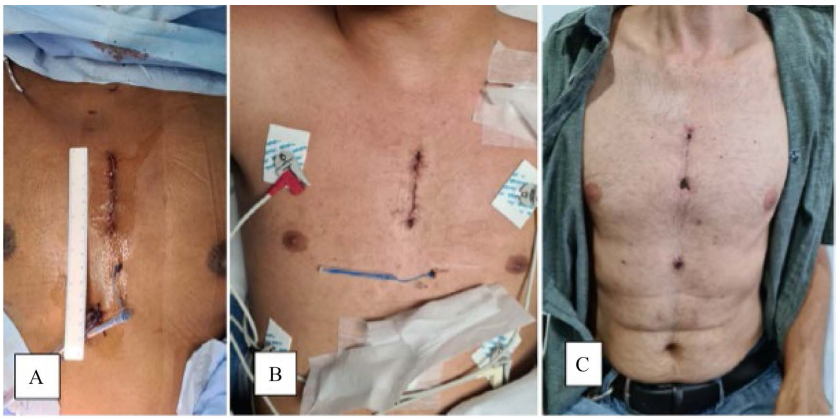

Figure 4. Postoperative aspects. A: patient at the end of surgery; B: patient on the 1st postoperative day; C: patient at the outpatient clinic 7 days after the procedure.

2.6. Statistical Analysis

The data were presented in tabular format, expressed by measures of central tendency and dispersion suitable for numerical data, and by frequency and percentage for categorical data. Normality of data distribution was verified by the Shapiro-Wilk test and graphical analysis of histograms. Statistical analysis was processed by the statistical software SPSS version 26.

3. Results

Eighteen patients were included in the study, with a mean age of 46.1 ± 15.6 years. Female patients represented 66,6% (n = 12), with an equal distribution of 45% each for black and white individuals (n = 9). The mean body mass index (BMI) was 22.1 ± 3.1 kg/m^2 and 50% (n = 10) had comorbidities. The cardiovascular diseases observed in the patients were: mitral regurgitation (8, 40.0%); mitral stenosis (5, 25%); ostium secundum-type atrial septal defect (3, 15.0%); sinus venosus atrial septal defect (2, 10.0%); myxoma (2, 10.0%).

The clinical characteristics of the study population are shown in Table 1.

ASD: atrial septal defect; BMI: body mass index; SD: standard deviation; SVC: superior vena cava.

The patients in the study presented with the following cardiovascular diseases: mitral regurgitation, not amenable to valve repair (complex anatomy), as deter-

mined by three-dimensional echocardiography (n = 6, 33,3%); mitral stenosis (n = 5, 27.7%); ostium secundum-type interatrial communication (n = 3, 16.6%); sinus venosus – superior vena cava interatrial communication (n = 2, 11.1%); and myxoma (n = 2, 11.1%) (Table 2).

Table 1. Clinical characteristics of the study population.

Variables		
Age, mean ± SD (years)		46.1 ± 15.6
Age group, n (%)	20 - 39	7 (38.8)
	40 - 59	8 (44.4)
	60 - 80	3 (16.6)
Gender, n (%)	Male	6 (30.0)
	Female	12 (66.6)
Ethnicity, n (%)	White	9 (50.0)
	Black	9 (50.0)
BMI, mean (SD), kg/m^2		22.1 ± 3.1
Comorbidities, n (%)	Yes	9 (50.0)
	No	9 (50.0)
Cardiovascular diseases n (%)	Mitral insufficiency	6 (33.3)
	Mitral stenosis	5 (27.7)
	Ostium secundum-type ASD	3 (16.6)
	Sinus venosus ASD	2 (11.1)
	Myxoma	2 (11.1)

Table 2. Cardiovascular diseases and comorbidities in the study population.

Cardiovascular diseases	Mitral regurgitation	6 (33.3%)
	Mitral stenosis	5 (27.7%)
	Ostium secundum-type interatrial communication	3 (16.6%)
	Sinus venosus atrial septal defect	2 (11.1%)
	Myxoma	2 (11.1%)
Comorbidities	Hypertension	2 (11.1%)
	Hypertension + atrial fibrillation	2 (11.1%)
	Hypertension + hypothyroidism	1 (5.5%)
	Hypothyroidism	1 (5.5%)
	Breast cancer	1 (5.5%)
	McCune-Albright syndrome	1 (5.5%)
	No comorbidities	9 (50%)

Half of the patients (50%) had comorbidities, with some individuals having more than one: hypertension (n = 2, 11, 1%); hypertension with atrial fibrillation (n = 2, 11, 1%); hypertension with hypothyroidism (n = 1, 5, 5%); hypothyroidism

(n = 1, 5, 5%); breast cancer (n = 1, 5, 5%); McCune Albright syndrome (n = 1, 5,5%) (Table 2).

Patients underwent one of the following surgical interventions: mitral valve replacement (n = 11, 61, 1%), atrial septal defect repair (n = 5, 27, 7%), and atrial myxoma resection (n = 2, 11, 1%).

Regarding the surgical procedure, the mean cardiopulmonary bypass (CPB) time was 78.2 ± 25.7 minutes and the mean aortic clamping time was 63.0 ± 24.0 minutes. Among the 18 patients studied, only 1 (5, 5%) required conversion to full median sternotomy due to difficulties in peripheral cannulation. Vasoactive drugs were administered to only 2 (11, 1%) patients, and there were no cases of stroke. No patients required pacemaker placement. There were no deaths. All patients were successfully extubated within an average time of three hours postoperatively. It is worth noting that extubation in the operating room is not a routine practice. In the postoperative period, there were no cases of surgical wound infection or sternal dehiscence. The length of stay ranged from 3 to 14 days, with a median of 4 days.

4. Discussion

For this study, a convenience sample was used, since the patient selection took place within the constraints of the Brazilian Unified Health System (SUS) and amidst the coronavirus pandemic. These factors limited the hospitalization of individuals meeting the pre-established inclusion criteria, which prioritized low operative risk and minimal comorbidities. Thus, the study population consisted of 18 patients with few comorbidities, classified as low surgical risk, who underwent a surgical approach to atrioventricular valves and septal defects through partial sternotomy.

Minimally invasive accesses are gaining prominence in cardiac surgery services, where the standard incision for heart manipulation has traditionally been the median sternotomy—a more invasive method associated with slow healing and a laborious clinical rehabilitation period lasting approximately three months [16] [17].

The present study proposed a technique based on the approach described and modified by Dumantepe *et al.* [7], who performed 16 procedures, 10 repairs of septal defects and 6 aortic valve replacements, with minimal skin incision and partial sternotomy to preserve the manubrium and its distal 1/3. The procedure used conventional materials and provided early patient recovery and the resumption of usual activities within 21 days of surgery. This approach aligns with existing literature on the previously mentioned techniques [18] [19].

In a study carried out during a similar period, Kaczmarczyk *et al.* [20] showed no difference between full sternotomy and ministernotomy regarding readmissions due to cardiac causes, stroke incidence, and long-term survival. The results of the current study indicate no instances of readmission, while long-term survival was not evaluated due to the need for a longer follow-up period for patients.

Additional data from studies comparing partial sternotomy access with full sternotomy is the need for blood components transfusion or the use of inotropic support [21]. In the present study, no blood component transfusions or inotropic support were necessary. As previously noted, the study population had few comorbidities and was at low operative risk, which likely contributed to these outcomes, given the distinct technique employed compared to those previously described.

An important aspect to note is the duration of surgical procedures, specifically cardiopulmonary bypass and aortic clamping times, which have historically been significantly longer in patients undergoing minimally invasive surgeries. However, this has been mitigated by the increased experience of surgical teams in these procedures [22]. Consequently, current literature reports equivalent times to conventional surgery, as well as conversion rates to conventional sternotomy [20]. In the present study, the reported times were consistent with those found in the literature, with one conversion to full sternotomy, which, while relatively the same rate as described in reviewed articles, may be attributed to the larger number of patients studied. Partial sternotomy is easily converted to full sternotomy, with no significant increase in surgical time.

One of the primary impacts of full median (traditional) sternotomy on quality of life in the postoperative period is the limitation it imposes on the upper limbs for broad movements, often requiring significant force, thereby delaying the patient's return to routine activities [10] [11]. Complications related to sternal wound infections occur in up to 8% of operations using the full median sternotomy approach, with an associated mortality rate of about 47% in late or undetected cases [12].

Comparing the presented results with those described for conventional sternotomy, it is evident that the study population experienced shorter hospital stays, while mortality rates were consistent with expectations for valve patients during the study period.

The results of this study show a technically feasible procedure with no significant increase in surgical time and good results regarding the absence of surgical site infection, sternal stability, and aesthetic results. Most patients returned to usual activities within the proposed time. While further studies with larger cohorts are needed to confirm the non-inferiority or potential superiority of this technique over conventionally performed surgeries, its appropriateness in well-indicated cases and in centers experienced in both conventional and minimally invasive procedures suggests that any challenges encountered can be readily addressed.

Study Limitations

Some limitations were identified in the present study.

The reduced sample size was a consequence of patient recruitment during the COVID-19 pandemic. Healthcare services were heavily burdened with treating

coronavirus-infected patients, functioning primarily for surgical emergencies or severe clinical cases. As a result, a convenience sample was obtained, and the number of patients recruited was limited to what could be recruited during the period described. The inclusion of patients with varying ages and comorbidities further constrained the study.

Furthermore, the study was not conducted in a comparative way, with the organization of a control group. Two facts contributed to this: firstly, as mentioned earlier, the challenges posed by the pandemic made it exceedingly difficult to recruit patients meeting the inclusion criteria for both the study and control groups. Moreover, establishing a control group with similar clinical characteristics to the study group became impractical during the pandemic. Additionally, the central idea of the work was on a novel surgical technique not described in the literature, which used data established for conventional surgery, as a comparative reference.

Another limitation is that even in patients with mitral regurgitation, our valve repair rate is low. We chose to select only candidates with complex valvular anatomy. Our hospital has a series of deficiencies, including a lack of materials, making complex repairs with extensive resections and the use of neocords unfeasible in our setting. The central idea of the study is to evaluate a new possibility for minimally invasive surgery using materials already employed in conventional surgeries and, despite our structural limitations, attempt to return patients to their daily routines in a timeframe and quality comparable to already established minimally invasive procedures.

5. Conclusions

The findings of this study suggest that partial sternotomy is a safe and effective alternative approach for atrioventricular valve surgery and atrial septal defect repair. This technique demonstrated feasibility, with no significant increase in operative time, and was associated with favorable outcomes, including sternal stability, reduced risk of surgical site infection, and enhanced postoperative recovery.

The preservation of the manubrium and the lower third of the sternum contributed to improved respiratory function, reduced postoperative pain, and facilitated early ambulation and extubation [11] [12]. Furthermore, the lower rate of wound complications highlights its potential advantage over conventional sternotomy, particularly in patients at higher risk for sternal dehiscence and mediastinitis [13] [14].

Despite these promising results, the study is limited by its single-center design and small sample size. Larger, multicenter trials with long-term follow-up are needed to further validate these findings and establish the comparative benefits of this technique against traditional full sternotomy [15] [16]. Additionally, further investigation is required to assess long-term durability, quality of life outcomes, and cost-effectiveness. If confirmed in larger studies, partial sternotomy may become a preferred approach for select patients undergoing cardiac surgery, balanc-

ing surgical exposure and minimally invasive advantages.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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