Comparison of the Effects of Conventional and Minimally Invasive Cardiac Surgery with Cardiopulmonary Bypass on Inflammatory, Hepatic and Renal Parameters

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Abstract

Aim: Cardiac surgery has been performed by conventional methods for many years, but in recent years, minimally invasive cardiac surgery has come to the forefront. The aim of this study was to evaluate the effects of conventional and minimally invasive cardiac surgery performed under CPB guidance on inflammatory, hepatic and renal parameters.

Methods: In this retrospective study, those who underwent conventional cardiac surgery with CPB were defined as Group 1 and those who underwent minimally invasive cardiac surgery were defined as Group 2. Descriptive data of the groups, preoperative and postoperative urea, creatinine, ALT, AST, GGT, WBC, CRP data which are indicators of inflammatory, hepatic and renal functions, and peroperative variables such as intubation time, ICU time and hospital stay time were evaluated.

Results: In this study, demographic data of the two groups were similar ($p > 0.05$). Preoperative and postoperative inflammatory, hepatic, renal parameters (urea, creatinine, WBC, CRP, AST, ALT, GGT), ICU time, hospital stay and mortality rates were also similar ($p > 0.05$). However, there were statistically significant differences between the groups in terms of duration of ACC ($p = 0.021$), total perfusion time ($p = 0.001$) and mechanical ventilation time ($p = 0.005$), and these values were higher in Group 2.

Conclusions: Minimally invasive cardiac surgery performed under CPB guidance was associated with longer ACC, total perfusion time and duration of mechanical ventilation compared to conventional cardiac surgery. However, inflammatory, renal and hepatic parameters showed similar results, although there were no significant differences.

Keywords: *Cardiopulmonary bypass; conventional bypass; minimally invasive bypass; inflammatory parameters; hepatic parameters; renal parameters*

1. Introduction

Recently, the increasing popularity of less invasive procedures has affected almost every surgical speciality, including cardiac surgery. Advances in imaging, surgical instrumentation and robotic technology have made it more usual for surgeons to perform complex cardiac surgery procedures through small incisions.[1] Cardiac surgery has been performed with conventional methods for many years, but different methods have come to the forefront in recent years. One of these is the minimally invasive cardiac surgery method. Many studies have supported many advantages of minimally invasive cardiac surgery compared to conventional approaches. These include improved cosmetic results, reduced postoperative pain levels, faster recovery time, and reduced need for blood product transfusion compared to cardiac surgery performed via sternotomy. Despite the potential advantages of minimally invasive cardiac surgery, available evidence, including randomised controlled trials and meta-analyses, has not demonstrated a significant difference in mortality between minimally invasive and conventional surgical approaches.[2-4]

In addition, there are still ongoing debates about the benefits of minimally invasive interventions[5]. Another point is that the superiority of the two methods over each other in terms of their effects on inflammation, hepatic parameters and renal parameters is controversial.

The aim of this retrospective study was to evaluate the effects of

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conventional and minimally invasive cardiac surgery performed under CPB guidance on inflammatory, hepatic and renal parameters.

2. Materials and Methods

This study is a retrospective clinical research.

2.1. Ethics Approval

In this study, approval was obtained from the institutions and the local ethics committee (Harran University Clinical Research Ethics Committee) (Date: 22.07.2024 - Approval no: HRÜ/24.10.18). The study was conducted following the principles of the Declaration of Helsinki. Since only anonymized patient data was used and there was no risk or impact on patient care, informed consent was not required. This consent waiver was approved by the Institutional Review Board and Ethics Committee and complies with regulatory and ethical guidelines for retrospective studies.

2.2. Study Design and Data Collection

The study included conventional and minimally invasive cardiac surgery patients who underwent CPB-guided cardiac surgery in the cardiovascular surgery clinic of Harran University Hospital between 01 January 2024 and 31 December 2024.

Those who underwent conventional cardiac surgery under CPB guidance were defined as the first group (Group 1), and those who underwent minimally invasive cardiac surgery were defined as the second group (Group 2).

Descriptive data of the groups (age, gender, height, weight, body surface area (BSA), flow, ejection fraction percentage (EF%), smoking, diabetes, hypertension, aortic cross clamp time, total perfusion time, surgical operation performed); urea, creatinine, alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma glutamyl transferase (GGT), white blood count (WBC), C-reactive protein (CRP) data, which are indicators of preoperative and postoperative inflammatory, hepatic and renal functions; and duration of intubation (duration of mechanical ventilation support), duration of intensive care unit (ICU) stay, and duration of hospital stay as peroperative variables.

2.3. Inclusion and Exclusion Criteria

Patients who underwent emergency cardiac surgery, patients who were scheduled for additional cardiac surgery such as aortic aneurysm or dissection, patients who underwent repeat cardiac surgery, patients with known systemic inflammatory disease, patients with chronic liver disease, chronic kidney disease or haemodialysis patients were excluded from the study.

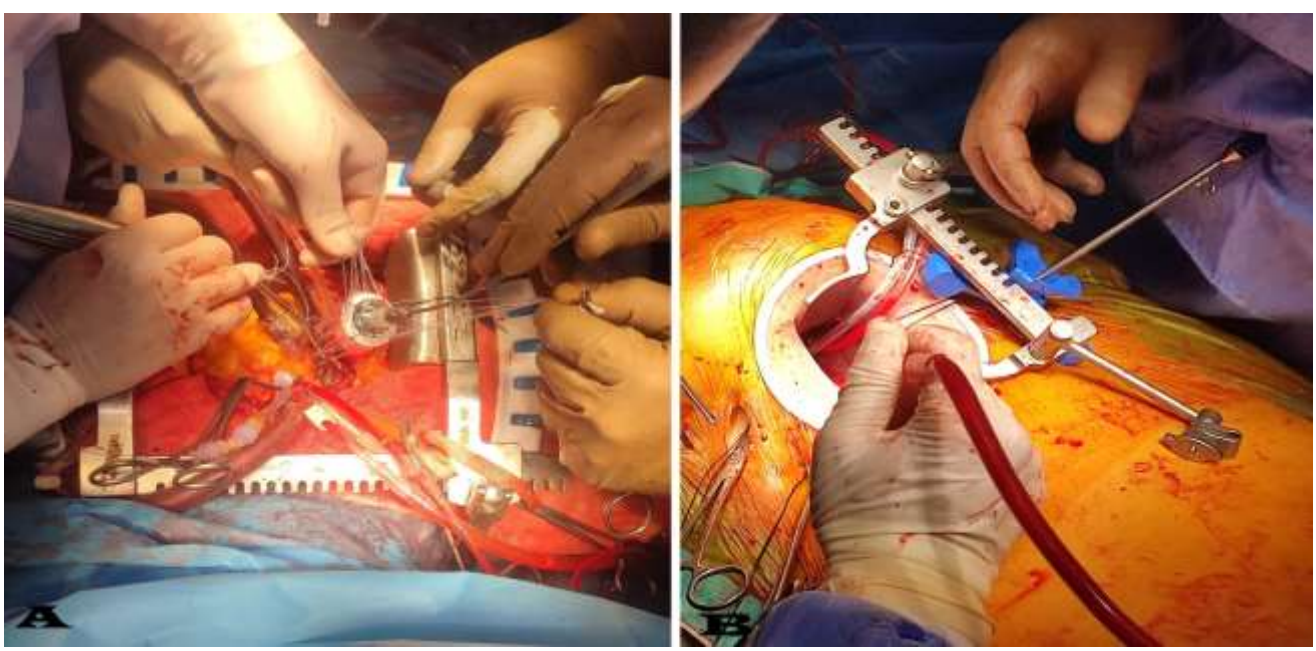
Patients of the last year in the centre where the study was performed were included consecutively after the exclusion criteria were applied. The included patients were adults aged between 18 and 85 years who underwent conventional and minimally invasive cardiac surgery under CPB guidance.

2.4. Conventional Cardiac Surgery Technique

Standard coronary and valvular heart surgery techniques were performed in all patients. After midline sternotomy in coronary heart surgery patients, arterial cannulation was performed from the ascending aorta and venous cannulation was performed from the right atrium with a single venous cannula (two stage venous conduit). Left mammary artery graft was used in all cases. Saphenous vein graft was applied to other coronary grafts. Complete revascularisation was performed in all patients. In valvular heart surgery patients, in addition to standard surgical techniques, in mitral valve replacements after midline sternotomy, arterial cannulation was performed from the ascending aorta and venous cannulation was performed with two venous cannulae from the vena cava superior and vena cava inferior (Bicaval cannulation). In aortic valve replacements, arterial cannulation was performed from the ascending aorta and venous cannulation was performed from the right atrium with a single venous cannula (two stage cannulation). Standard extracorporeal circulatory systems (heart-lung machine) were also used (Figure 1-A).

Figure 1

A: Conventional method of cardiac surgery, B: Minimally invasive cardiac surgery method



2.5. Minimally Invasive Cardiac Surgery Technique

In all patients undergoing minimally invasive cardiac surgery, arterial cannulation was performed via femoral artery and venous cannulation was performed via femoral vein and right jugular vein cannulations and cardiopulmonary bypass was performed. Cardiopulmonary bypass was performed with antegrade cardioplegia delivered from the aorta using a long cardioplegia cannula and del nido cardioplegia solution was used in all patients. In all cases, aortic clamping was performed with an aortic clamp delivered through an approximately 1 cm long incision made in the 2nd intercostal space. For patients undergoing coronary artery graft surgery, a left internal mammary artery (LIMA) graft was prepared and a special retractor was used for this procedure, followed by the use of a standard retractor for distal and proximal anastomoses. Proximal anastomoses were routinely performed to the aorta under aortic cross clamp.

Coronary artery graft surgery was performed through an approximately 5 cm long incision starting from the left 4th intercostal space adjacent to the sternum; aortic valve replacement was performed through an approximately 5 cm long incision starting from the right 2nd or 3rd intercostal space adjacent to the sternum; and mitral valve replacement was performed through a relatively lateral approximately 5 cm long incision in the right 5th intercostal space (Figure 1-B).

In all minimally invasive cardiac surgery patients, 1 thoracic drainage tube and 1 flat drain placed adjacent to the aorta were used as standard. In all minimally invasive operations, patients were intubated with a double lumen intubation tube as standard, the lung on the side of the approach was deflated, and standard endotracheal intubation was returned at the end of the operation.

2.6. Statistical Analyses

Statistical analyses were conducted using the SPSS® 17.0 computer programme (version 17.0, SPSS, Chicago, IL, USA). Means and standard deviations were calculated for continuous data. Kolmogorov Smirnov test and Shapiro-Wilk test were used to evaluate normality distribution. Student T test and Mann Whitney U tests were used to evaluate normal and non-normally distributed data, respectively. Frequency and percentage analyses were performed for nominal data and Chi-Square test and Chi-Square corrected test were used for comparison. A 'p' value less than 0.05 was considered statistically significant.

3. Results

Although certain differences were observed between the two groups in terms of variables such as age, body weight and EF%, statistical analyses showed that these differences were not significant ($p > 0.05$). Furthermore, no statistically significant differences were found between the groups in terms of gender distribution, types of surgical procedures, smoking and prevalence of chronic diseases ($p > 0.05$). These findings indicate that both groups were similar in terms of basic demographic and clinical characteristics (Table 1).

Table 1

Demographic and descriptive data of the groups

Variables		Group 1 N=51	Group 2 N=42	Test Statistics	P
Age (Year) (Mean±SD)		61.25±9.61	66.35±7.05	-2.863	0.075 [a]
Height (cm) (Mean±SD)		171.70±9.06	170.21±9.76	0.762	0.609 [a]
Weight (kg) (Mean±SD)		81.62±11.99	75.52±14.93	2.186	0.096 [a]
BSA (Mean±SD)		1.93±0.14	1.86±0.18	1.946	0.055 [a]
Flow (L) (Mean±SD)		4.64±0.18	4.47±0.66	1.768	0.080 [a]
Preoperative % EF (Mean±SD)		51.62±8.48	44.80±10.23	3.513	0.223 [a]
Gender (n, %)	Male	30, (58.8%)	28, (66.7%)	0.604	0.437 [b]
	Female	21, (41.2%)	14, (33.3%)		
Surgical Type (n, %)	*CABGx1	4, (7.8%)	5, (11.9%)	3.586	0.610 [c]
	*CABGx2	6, (11.8%)	8, (19.0%)		
	*CABGx3	20, (39.2%)	12, (28.6%)		
	*CABGx4	12, (23.5%)	12, (28.6%)		
	· AVR	5, (9.8%)	4, (9.5%)		
	· MVR	4, (7.8%)	1, (2.4%)		
Smoking (n, %)	· None	35, (68.6%)	33, (78.6%)	1.159	0.282 [b]
	· Yes	16, (31.4%)	9, (21.4%)		
Hypertension (n, %)	· None	14, (27.5%)	17, (40.5%)	1.758	0.185 [b]
	· Yes	37, (72.5%)	25, (59.5%)		
COPD (n, %)	· None	45, (90.2%)	38, (90.5%)	0.000	1.000 [c]
	· Yes	5, (9.8%)	4, (9.5%)		
Diabetes Mellitus (n, %)	· None	27, (52.9%)	22, (52.4%)	0.003	0.957 [b]
	· Yes	24, (47.1%)	20, (47.6%)		
Hyperlipidemia (n, %)	· None	31, (60.8%)	30, (71.4%)	1.156	0.282 [b]
	· Yes	20, (39.2%)	12, (28.6%)		

[a]: Independent sample T-test, [b]: Chi-Square Test, [c]: Chi-square corrected test, Mean±SD: Mean±Standard Deviation, n: Frequency, %: Percent, BSA: Body Surface Area, EF: Ejection Fraction, COPD: Chronic Obstructive Pulmonary Disease.

Table 2

Comparison of inflammatory, hepatic, renal parameters and early clinical results of the groups

Variables	Group 1 N=51 (Mean±SD)	Group 2 N=42 (Mean±SD)	Test Statistics	P
Preoperative urea (mg/dL)	28.71±12.08	31.46±12.81	-1.064	0.290 [a]
Postoperative urea (mg/dL)	40,96±18,85	43,98±19,24	-0.936	0.349 [d]
Preoperative creatine (mg/dL)	0.91±0.25	0.94±0.27	-0.390	0.698 [a]
Postoperative creatine (mg/dL)	0.97±0.39	1,01±0.43	-0.479	0.632 [d]
Preoperative WBC (10^3µl)	6,95±2,93	7,04±3,28	-0.035	0.972 [d]
Postoperative WBC (10^3µl)	8,75±4,66	7,65±3,75	-0.967	0.333 [d]
Preoperative CRP (mg/L)	2,23±3,58	2,25±3,72	-0.116	0.908 [d]
Postoperative CRP (mg/L)	29,65±32,77	26,11±31,52	-0.405	0.685 [d]
Preoperative AST (U/L)	46,60±40,06	44,47±40,89	-0.421	0.674 [d]
Postoperative AST (U/L)	86,07±84,34	85,64±87,03	-0.085	0.932 [d]
Preoperative ALT (U/L)	29,50±21,92	27,78±17,73	-0.151	0.880 [d]
Postoperative ALT (U/L)	39,43±46,39	37,42±41,31	-0.093	0.926 [d]
Preoperative GGT (IU/L)	24.37±14.38	29.14±20.24	-1.325	0.188 [a]
Postoperative GGT (IU/L)	34,76±20,20	35,78±19,02	-0.340	0.734 [d]
ACC time (min)	56.17±19.59	64.50±18.40	-2.306	0.021 [d]
Total perfusion time (min)	94.52±34.46	118.54±45.10	-3.329	0.001 [d]
Mechanical ventilation support time (hours)	6.86±2.32	8.88±3.72	-2.805	0.005 [d]
ICU time (days)	2.68±0.86	2.69±1.27	-0.669	0.504 [d]
Duration of Hospitalisation (days)	11.80±3.51	10.35±4.74	1.689	0.095 [a]
Mortality (Postoperative 30-day period)	0.00±0.00	0.02±0.15	-1.102	0.270 [d]

[a]: Independent sample T-test, [d]: Mann-Whitney U test, Mean±SD: Mean±Standard Deviation, WBC: White blood count, CRP: C-reactive protein, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, GGT: Gamma glutamyl transferase, ACC: Aortic cross clamp, ICU: Intensive Care Unit.

As shown in Table 2, there was no statistical difference between the groups in terms of preoperative and postoperative inflammatory, hepatic, renal parameters (urea, creatinine, WBC, CRP, AST, ALT, GGT), ICU time, hospital stay and mortality rates and the results were similar ($p > 0.05$). However, there were statistically significant differences between the groups in terms of aortic cross clamp (ACC) time ($p = 0.021$), total perfusion time ($p = 0.001$) and mechanical ventilation time ($p = 0.005$) and these values were higher in Group 2 (Table 2).

4. Discussion

This study aimed to compare the effects of conventional and minimally invasive cardiac surgery performed under CPB guidance on inflammatory, hepatic and renal parameters. In the study, important findings were obtained in the comparison of demographic, clinical and postoperative variables between two different patient groups. Although certain differences were observed in some variables such as age, weight and EF% between the two groups, no statistically significant difference was found. However, a statistically significant increase was observed in Group 2 in terms of ACC time, total perfusion time and mechanical ventilation time, which are of great importance in CPB-guided cardiac surgery ($p < 0.05$). These results suggest that the surgical process lasted longer in Group 2 and the postoperative recovery process of the patients required more support. These findings show the superiority of our study. There was no significant difference between the two groups in terms of length of hospital stay, ICU stay and mortality rates. This indicates that postoperative care processes were similar for both groups and there was no significant change in complication rates. There was no significant difference between the groups in terms of preoperative and postoperative biochemical parameters (urea, creatine, GGT, WBC, CRP, AST, ALT). These results suggest that the metabolic responses before and after surgery are similar.

Compared with previous studies, it has been suggested that prolongation in the duration of ACC and total perfusion time may increase the risk of postoperative complications.[6-8] However, no significant difference in mortality was found in this study, indicating that surgical and postoperative care was managed effectively for both groups. Therefore, despite the longer perfusion times and duration of mechanical ventilation, there was no significant difference in the overall postoperative course of the patients.

In terms of haematological and biochemical parameters, no significant difference was found between the groups in terms of preoperative and postoperative WBC and CRP levels. However, the literature suggests that the use of CPB triggers systemic inflammatory response syndrome (SIRS), which may be associated with postoperative complications. However, it has been reported that minimally invasive surgery is associated with smaller surgical incision and lower inflammatory response.[9,10] In our study, the minimally invasive surgery group had lower WBC and CRP levels, although not statistically significant. Our findings support this literature data and suggest that minimally invasive surgery has the potential to reduce the inflammatory process.

In terms of hepatic and renal parameters, preoperative and postoperative AST, ALT, GGT, urea and creatinine levels were not significantly different between the groups. However, an increase in AST and ALT levels was observed in both groups in the postoperative period. Plasma AST and ALT levels are within normal limits in the healthy population. These parameters are usually affected by coronary heart disease, impaired renal function and various drugs.[11] This reflects the effect of CPB on hepatic and renal functions. In our study, hepatic and renal functions were better

preserved in the minimally invasive cardiac surgery group, but this difference was not statistically significant.

There are many studies in the literature comparing conventional and minimally invasive cardiac surgery.[12-19] However, there is still no consensus on the results.

Akowuah et al.[12] compared minithoracotomy and conventional sternotomy methods in mitral valve repair. In their study, they compared the safety and efficacy of minithoracotomy and sternotomy mitral valve repair. As a result of their study, they reported that minithoracotomy was not superior to conventional sternotomy in the recovery of physical function at 12 weeks. They also reported that minithoracotomy provided valve repair at high rates and quality and had similar safety results to conventional sternotomy at 1 year.[12] Bratt et al.[13] compared the bleeding rates of the two methods in minimally invasive and conventional aortic valve replacement. At the end of their study, they reported that minimally invasive aortic valve replacement did not lead to less bleeding-related outcomes compared to complete sternotomy[13]. Similarly, Hancock et al.[14] compared mini sternotomy with conventional sternotomy for aortic valve replacement in their study. At the end of their study, they reported that aortic valve replacement performed by mini sternotomy did not decrease red blood cell transfusion within 7 days after surgery compared with conventional sternotomy.[14] Telyuk et al.[15] reported that there was no significant difference between limited mini sternotomy and conventional sternotomy in terms of all-cause mortality, reoperation rate, myocardial infarction, coronary vascularisation or death from any cause (MACE events) and echocardiographic data at a median follow-up of 6.1 years.[15] There are studies showing different results from these studies.[16-19] One of these studies is the study by Filip et al.[16] In their study, they compared the perioperative and postoperative results of aortic valve replacement operations performed by conventional full sternotomy and partial upper sternotomy in isolated aortic valve replacement. As a result of their study, they reported that ministernotomy in aortic valve replacement did not increase morbidity and mortality and significantly decreased postoperative blood loss and shortened hospital stay. They also stated that ministernotomy can be used successfully as an alternative method to sternotomy.[16] Another study in the literature states that minimally invasive aortic valve replacement provides equivalent results at a lower cost compared to conventional aortic valve replacement. The study also reported that the mortality and morbidity results of the two methods were similar. However, it was also reported that minimally invasive aortic valve replacement was associated with a decrease in ventilator time, blood product use, early discharge and total hospital cost.[17] In another study, similar to our study, it was reported that minimally invasive cardiac surgery was associated with longer CPB times. However, they reported that the incidence of low cardiac output syndrome and atrial fibrillation was lower in minimally invasive cardiac surgery.[18] In a study investigating the effect of these two methods on quality of life, it was reported that ministernotomy provided a faster improvement in quality of life and satisfaction in the first month compared to full sternotomy.[19]

When the data in our study and different studies in the literature are evaluated, it is thought that there is a need for further research on these two methods.

4.1. Limitations

This study has several important limitations. Firstly, the single-centre and retrospective design of the study limits the generalisability of the findings. This structure may limit the direct applicability of the results in other centers, given the surgical protocols, patient management strategies and standards of care applied in different institutions. Furthermore, possible selection bias during patient selection cannot be ruled out; in particular, the fact that patients eligible for minimally invasive surgery are selected according to specific clinical criteria may create imbalance in comparative analyses.

The level of experience of the surgical teams and technical differences may also have affected the results; this variability could not be controlled. In addition, more comprehensive analyses were not possible due to the lack or inadequacy of some laboratory and clinical parameters. In line with these limitations, the findings of this study should be interpreted with caution and should be supported by prospective, prospective, multicenter and randomised controlled trials.

5. Conclusion

In conclusion, minimally invasive cardiac surgery performed under CPB guidance was associated with longer ACC time, total perfusion time and mechanical ventilation time compared to conventional cardiac surgery. In this respect, conventional cardiac surgery is still considered superior. However, although there were no significant differences in inflammatory, renal and hepatic parameters, they showed similar results. Future randomised controlled trials with larger patient groups will contribute to a better understanding of these findings.

Statement of ethics

In this study, approval was obtained from the institutions and the local ethics committee (Harran University Clinical Research Ethics Committee) (Date: 22.07.2024 - Approval no: HRÜ/24.10.18). The study was conducted following the principles of the Declaration of Helsinki. Since only anonymized patient data was used and there was no risk or impact on patient care, informed consent was not required. This consent waiver was approved by the Institutional Review Board and Ethics Committee and complies with regulatory and ethical guidelines for retrospective studies.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Author contributions

MZB and BA is the major contributor to the writing of the manuscript. MZB and BA are involved in the design, conception, data collection and analysis of the study. All authors read and approved the final version of the manuscript.

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