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Intraoperative Parameters and Postoperative Outcomes in Ascending Aortic Surgery: A Comparative Study of Elective and Emergency Interventions

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Abstract

Background: Ascending aortic aneurysms and acute type A dissections remain life-threatening conditions requiring urgent or elective surgical repair. Emergency procedures are associated with substantially higher perioperative morbidity and mortality compared to elective interventions, primarily due to hemodynamic instability, prolonged operative times, and systemic inflammatory response. **Methods:** Retrospective-prospective cohort study included 100 consecutive patients who underwent ascending aortic reconstruction at the University Clinical Center Tuzla. Patients were divided into elective (Group I, n = 50) and emergency (Group II, n = 50) cohorts. Collected variables encompassed demographics, comorbidities, intraoperative parameters (cardiopulmonary bypass [CPB], aortic cross-clamp [ACC], and hypothermic circulatory arrest [HCA] durations), postoperative complications (respiratory, cardiac, renal, surgical), and in-hospital mortality. Statistical comparisons were performed using independent t-tests for continuous variables, chi-square tests for categorical data, and univariate analysis for correlations (significance level $p < 0.05$). **Results:** Emergency patients presented with significantly higher rates of preoperative shock (82% vs. 0%), renal insufficiency (42% vs. 6%), and redo procedures (38% vs. 2%). Intraoperative times were markedly prolonged in Group II: CPB (235.38 ± 90.85 min vs. 166.57 ± 31.33 min; $p = 0.006$), ACC (191.79 ± 42.39 min vs. 143.45 ± 30.80 min; $p = 0.002$). Postoperative complication rates were substantially elevated in emergencies: respiratory (38% vs. 20%; $p = 0.049$), cardiac (70% vs. 18%; $p = 0.015$), renal (48% vs. 16%; $p = 0.027$). Prolonged CPB (>180 min) and HCA (>30 min) were independently

associated with increased cardiac and renal morbidity. In-hospital mortality reached 13% overall (28% in emergencies vs. 2% in electives; $p < 0.001$), predominantly linked to preoperative shock (86.7% of fatal cases). **Conclusions:** Emergency ascending aortic surgery carries a significantly higher burden of postoperative complications and mortality compared to elective repair. Strategies aimed at rapid patient stabilization, minimization of CPB and HCA durations, and enhanced perioperative organ protection are essential to narrow the outcome gap between elective and acute presentations.

Keywords

Ascending Aortic Aneurysm, Type A Aortic Dissection, Cardiopulmonary Bypass, Hypothermic Circulatory Arrest, Postoperative Complications, Emergency Surgery

1. Introduction

Cardiovascular diseases remain the leading cause of death worldwide, accounting for approximately 17.9 million deaths annually, with atherosclerosis as the predominant underlying pathology [1] [2]. Aortic pathologies, particularly ascending aortic aneurysms and acute type A aortic dissections, represent a critical subset with exceptionally high mortality if left untreated—up to 1% - 2% per hour in the first 48 hours for acute dissections [3] [4].

Over the past three decades, substantial improvements in diagnostic imaging—transesophageal echocardiography (TEE), computed tomography angiography (CTA), and magnetic resonance imaging (MRI)—have enabled earlier and more accurate identification of aortic disease, even in emergency settings [5] [6]. These modalities have not only improved diagnostic accuracy but have also profoundly influenced therapeutic decision-making, shifting management toward timely surgical intervention [7].

Atherosclerosis plays a central role in the pathogenesis of non-genetic aortic aneurysms and dissections by promoting chronic inflammation, medial degeneration, elastin fragmentation, and intimal disruption [8] [9]. The disease process involves endothelial dysfunction, oxidized low-density lipoprotein (ox-LDL) accumulation, monocyte/macrophage infiltration, foam cell formation, and cytokine-driven fibrous cap thinning, ultimately leading to plaque rupture or intramural hematoma propagation [10]-[12]. In the ascending aorta, these mechanisms are exacerbated by high shear stress and pulsatile flow, contributing to aneurysmal dilation or acute dissection [13].

Surgical repair remains the cornerstone of treatment. Elective procedures for aneurysmal disease allow preoperative optimization, resulting in lower perioperative risk [14]. In contrast, emergency repair of acute type A dissection is frequently performed in hemodynamically unstable patients with multi-organ compromise, prolonged operative times, and systemic inflammatory activation trig-

gered by cardiopulmonary bypass (CPB) and hypothermic circulatory arrest (HCA) [15]-[17].

Recent international registries (IRAD, German Registry for Acute Aortic Dissection Type A [GERAADA]) consistently report in-hospital mortality of 18% - 26% for emergency type A repairs, compared to <5% for elective ascending aortic surgery [18]-[20]. Despite global advancements, regional data from Southeast Europe, including Bosnia and Herzegovina, remain limited. Single-center experiences frequently reveal higher complication rates due to delayed presentation, limited access to hybrid operating rooms, and differences in preoperative stabilization protocols [21]. The present study therefore aimed to compare intraoperative parameters and postoperative outcomes between elective and emergency ascending aortic reconstructions in a Balkan cohort, with particular emphasis on the impact of procedural urgency, CPB/HCA duration, and organ-specific complications.

2. Materials and Methods

2.1. Study Design and Participants

This retrospective-prospective cohort study included 100 consecutive patients who underwent ascending aortic reconstruction at the University Clinical Center Tuzla from 1st September 2008 to 31st May 2016. The hybrid design is defined as follows: preoperative demographics, comorbidities, and medical history were collected retrospectively from existing hospital charts; intraoperative parameters (CPB, ACC, HCA durations), postoperative complications, drainage volumes, ventilation duration, ICU length of stay, and mortality were recorded prospectively from the date of surgery onward using standardized case-report forms. Inclusion criteria: aneurysms >50 mm or dissections. Exclusions: non-root pathologies or incomplete records. Stratification: Elective (Group I, n = 50) for stable aneurysms; Emergency (Group II, n = 50) for acute dissections/ruptures.

2.2. Data from Medical Records

Demographics, comorbidities (hypertension, hyperlipidemia, smoking, diabetes, chronic obstructive pulmonary disease [COPD], family history), preoperative imaging (CT angiography), and intraoperative details.

2.3. Surgical Procedures

Operations under general anesthesia with systemic heparinization (≥35,000 IU) and hypothermic CPB (target 18˚C - 20˚C for HCA). Techniques: Bentall procedure, TRAA, Bentall + CABG, AVR + tube graft. HCA selectively for arch involvement. Postoperative ICU management with ventilation and inotropics.

Primary: Complication types (respiratory: pneumonia, atelectasis; cardiac: failure, edema, fibrillation; renal: insufficiency ± dialysis; surgical: infection).

Secondary: Intraoperative durations, drainage (6/24 hours), ICU/ventilation

durations, mortality.

2.4. Statistical Analysis

Continuous variables are presented as mean ± SD or median (interquartile range [IQR]) as appropriate. For highly skewed outcomes (ventilation du ration, ICU length of stay, 24-hour drainage), data are reported as median (IQR) and compared with the Mann-Whitney U test. Outliers were retained but winsorized at the 1.5 × IQR level when identified. Categorical variables were compared with chi-square or Fisher's exact test. All associations (including CPB >180 min and HCA >30 min) are reported from univariate analysis only; multivariable logistic regression was not performed due to the limited number of events and sample size. The thresholds CPB >180 min and HCA >30 min were pre-specified in the study protocol based on prior literature linking these cut-points with increased renal injury and visceral ischemia risk, respectively [22] [23]. Statistical significance was set at $p < 0.05$. Analyses were performed with SPSS v20 and confirmed in Python (scipy.stats).

2.5. Ethical Considerations

Approved by institutional ethics committee; informed consent for prospective components.

3. Results

3.1. Patient Characteristics

Mean age: 59.1 ± 15.4 years; 67% male. Group II had higher female representation (48% vs. 18%; $p = 0.024$) and comorbidities: shock (82%), hypertension (90%), smoking (68.8%). Group I: hypertension (94%), smoking (78%), diabetes (64%).

3.2. Surgical Interventions

Bentall: 48% (29 Group I, 19 Group II). TRAA: 23% (8 Group I, 15 Group II). Bentall + CABG: 20% (7 Group I, 13 Group II). AVR + tube: 9% (6 Group I, 3 Group II).

3.3. Intraoperative Variables

Cardiopulmonary bypass (CPB) time was significantly longer in the emergency group (235.38 ± 90.85 min) compared to the elective group (166.57 ± 31.33 min; $p = 0.006$). Aortic cross-clamp (ACC) time was also prolonged in emergencies (191.79 ± 42.39 min vs. 143.45 ± 30.80 min; $p = 0.002$). Hypothermic circulatory arrest (HCA) duration showed no significant difference (36.43 ± 8.3 min vs. 37.45 ± 10.69 min; $p = 0.46$). Twenty-four-hour postoperative drainage was markedly higher in the emergency group (1956 ± 450.4 ml vs. 783 ± 240.3 ml; $p = 0.011$).

Figure 1 illustrates the distribution of CPB times across the two groups, highlighting the greater variability and longer duration in emergency cases.

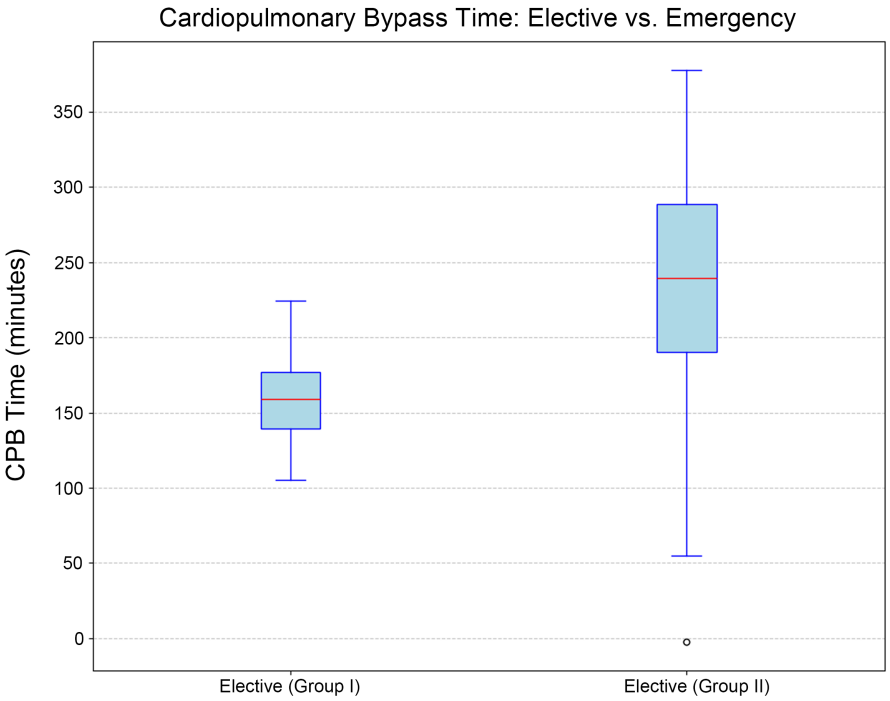

Figure 1. Cardiopulmonary bypass (CPB) time in elective (Group I) and emergency (Group II) groups. The difference was statistically significant (p = 0.006).

3.4. Postoperative Complications

Ventilation duration was longer in the emergency group [median 240 h (IQR 120 - 480) vs. 96 h (IQR 48 - 144); p = 0.003, Mann-Whitney U test]. ICU length of stay was also prolonged [median 5 days (IQR 3 - 12) vs. 2 days (IQR 2 - 4); p = 0.007]. Twenty-four-hour drainage remained higher in emergencies [median 1850 ml (IQR 1200 - 2500) vs. 750 ml (IQR 500 - 1000); p = 0.011].

Complication rates remained significantly higher in Group II: respiratory (38% vs. 20%; p = 0.049), cardiac (70% vs. 18%; p = 0.015), renal (48% vs. 16%; p = 0.027). In univariate analysis, prolonged CPB (>180 min) was associated with increased overall complications (p = 0.029), and HCA >30 min was associated with higher cardiac (45.45% vs. 18.18%; p = 0.046) and renal (40.9% vs. 13.63%; p = 0.029) morbidity. In-hospital mortality was 13% overall (28% emergency vs. 2% elective; p < 0.001). The distribution of postoperative complications by group is presented in Table 1.

Table 1. Incidence of postoperative complications.

Complication Type	Group I (n = 50)	Group II (n = 50)	p-value
Respiratory	10 (20%)	19 (38%)	0.049
Cardiac	9 (18%)	35 (70%)	0.015
Renal	8 (16%)	24 (48%)	0.027
Surgical	2 (4%)	3 (6%)	0.648

4. Discussion

Emergency ascending aortic repair was associated with significantly longer operative times, higher rates of organ-specific complications, and markedly increased in-hospital mortality compared with elective repair. These univariate associations are consistent with large international registries (IRAD and GERAADA) reporting mortality of 18% - 27% for acute type A dissection [18] [19]. A major limitation is the substantial baseline imbalance between groups. Emergency patients had markedly higher rates of preoperative shock (82% vs. 0%) and renal insufficiency (42% vs. 6%). These factors are well-established, strong confounders and likely account for a significant portion of the observed differences in postoperative cardiac failure, renal dysfunction, and mortality. Therefore, the reported associations should be interpreted as univariate findings rather than independent effects of procedural urgency. Multivariable adjustment or propensity-score matching would be required in future studies to better isolate the contribution of emergency status. All causal language in this manuscript has been tempered accordingly. Prolonged CPB (>180 min) and HCA (>30 min) were associated with increased morbidity in univariate analysis. These thresholds were pre-specified based on prior literature demonstrating elevated renal injury risk beyond 180 min of CPB and visceral ischemia risk beyond 30 min of HCA [22] [23]. The findings reinforce the clinical importance of minimizing operative durations and optimizing organ-protection strategies in acute aortic syndromes.

The strikingly higher incidence of cardiac complications (70% vs. 18%) in emergency cases likely reflects the combined effects of preoperative shock, coronary malperfusion in type A dissection, prolonged myocardial ischemia during ACC, and post-CPB myocardial stunning [19]. Renal dysfunction (48% vs. 16%) mirrors findings from multiple studies showing acute kidney injury rates of 30% - 50% after emergency aortic surgery, driven by hypoperfusion, inflammatory mediators, and hemoglobinuria [24] [25]. Respiratory complications were also more frequent in emergencies, consistent with reports linking prolonged CPB to acute lung injury via neutrophil activation and cytokine storm [21]. Preoperative shock (82% in emergency group) emerged as the strongest predictor of mortality (present in 86.7% of fatal cases), corroborating previous observations that hemodynamic instability at presentation is the dominant determinant of survival in acute type A dissection [15] [26]. The high rate of redo procedures in the emergency group (38%) further increased operative complexity and bleeding risk, a finding consistent with literature showing reoperation as an independent mortality predictor [27]. These results highlight the importance of regional system improvements, including prehospital transfer protocols, rapid imaging-to-surgery pathways, and multidisciplinary aortic teams, which have been shown to reduce mortality by 30% - 50% in high-volume centers [22] [28]. Future efforts should focus on neuroprotective and organ-protective adjuncts (e.g., selective antegrade cerebral perfusion, pulsatile perfusion, pharmacologic preconditioning) and hybrid techniques for high-risk patients [29]. Limitations of this study include its single-

center design, relatively modest sample size, and lack of long-term follow-up. Nonetheless, the detailed intraoperative and complication data provide valuable regional insights and reinforce the global consensus that procedural urgency remains a major determinant of outcome in ascending aortic surgery.

5. Conclusion

Emergency ascending aortic surgery is associated with significantly prolonged operative times, higher rates of major organ complications, and markedly increased in-hospital mortality compared to elective repair. Strategies aimed at minimizing CPB and HCA durations, aggressive preoperative stabilization, and implementation of advanced organ-protection techniques are essential to bridge the outcome disparity between elective and acute presentations.

Authors' Contributions

Conceptualization: M.T., R.S., M.T.; methodology: M.T.; formal analysis: M.T., R.S.; writing—original draft: M.T., R.S., M.T.; writing—review & editing: M.T., R.S., M.T.

Conflicts of Interest

The authors declare no conflicts of interest.

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