Surgical outcomes of acute type A aortic dissection in dialysis patients: lessons learned from a single-center’s experience

Zhigang Wang1,4, Pingping Ge2,4, Lichong Lu1,4, Min Ge1, Cheng Chen1, Lifang Zhang3 & Dongjin Wang1*

There is a paucity of data describing the safety and efficacy of acute type A aortic dissection (ATAAD) repair surgeries in dialysis patients. Our study aimed to investigate the influence of dialysis on early and late outcomes in end-stage renal disease (ESRD) patients who received repair surgery for ATAAD. A total of 882 ATAAD patients who received emergency aortic dissection repair at our center from January 2015 to December 2019 were retrospectively screened in this study and divided into the dialysis group (n = 16) and the non-dialysis group (n = 866), depending on whether they required dialysis for preoperative ESRD. No significant difference of age, preoperative hemodynamics, organ ischemia conditions, operative variables as well as the 30-Day mortality and in-hospital complications was discovered between two groups. However, the survival rates and the proportion of late aortic event (sudden death and reoperation) free population at 1 and 3 years after surgery were significantly decreased in dialysis patients compared to non-dialysis patients. Our study indicated that the short-term surgical outcomes of ATAAD in dialysis patients were comparable to non-dialysis patient. However, the dialysis patients were associated with a worse long-term prognosis.

It has been well studied that patients with end-stage renal disease (ESRD) associate with decreased life expectancy and are more vulnerable to develop cardiovascular events compared to healthy individuals1–3. As a well-established treatment method, increasing ESRD patients are receiving regular dialysis treatment. In 2010, the incidence and prevalence of patients who require hemodialysis were 147.3/million and 509/million in Beijing4.

Acute type A aortic dissection (ATAAD) is a critical disease that often associates with lethal outcomes. It often progresses rapidly and develops life-threatening complications, such as aortic rupture and cardiac tamponade5. Although outcomes of ATAAD have been improving in recent years due to the advance of techniques6, it is still a dangerous condition, especially in patients with other comorbidities like ESRD. The hemodynamic and electrolytes homeostasis is often disturbed under dialysis which posts additional challenges for the surgical repair of ATAAD7. However, the outcomes of such patients had not been well described. In this study we described both the short- and long-term outcomes of dialysis patients who received ATAAD repair surgery.

Methods and materials

A total of 882 consecutive patients who received emergent ATAAD surgery at Nanjing Drum Tower Hospital between January 2015 and December 2019 were retrospectively screened for this study. The diagnosis of ATAAD was made on the basis of enhanced computed tomography and the acute ATAAD was characterized as patients within 14 days of symptom onset. Among all 882 patients, 16 patients were receiving hemodialysis or peritoneal dialysis therapy for ESRD before the onset of aortic dissection. No patients received renal transplantation before the onset of the ATAAD.

The 882 patients were divided into two groups according to whether they were receiving dialysis therapy before the surgery (dialysis group, n = 16; non-dialysis group, n = 866). Patients’ medical records and imaging results were reviewed. The institutional review board of the Nanjing Drum Tower Hospital approved this study.

1Department of Cardio-Thoracic Surgery, Affiliated Drum Tower Hospital, Medical School of Nanjing University, Zhongshan Road 321, Nanjing 210008, China. 2Department of General Practice, Nanjing First Hospital, Nanjing Medical University, Nanjing, China. 3Department of Psychiatry, The First Affiliated Hospital, Zhengzhou University, Zhengzhou, China. *These authors contributed equally: Zhigang Wang, Pingping Ge and Lichong Lu. ‡email: glyywdj@163.com
dialysis patients were more likely to receive root construction, compared to patients in the non-dialysis group. Surgical techniques, and cardiopulmonary bypass duration were similar between the two groups. However, 

\( p = 0.009 \). Interestingly, no significant difference was identified in preoperative hemodynamic measurements and organ malperfusion conditions between the two groups. On the other hand, the levels of leukocyte count, haemoglobin, creatinine, and blood urea nitrogen were significantly different between the two groups. In addition, we found out a clear trend that dialysis patients were more likely to have primary entry tear in the aortic arch, even though the difference was not statistically significant.

The ATAAD repair surgery were carried out as described previously. Briefly, surgical procedures including routine median sternotomy, cardiopulmonary bypass, and intermittent cardiopulmonary arrest with hypothermic circulatory arrest were conducted similarly between two groups. Appropriate distal surgical method was chosen depending on the location of the intimal tear and the extent of dissection. For the proximal segment, a root reinforcement reconstruction was routinely performed. The aortic valve replacement or Bentall procedure was performed when the dissection involved the coronary ostia or aortic valve, or was in the presence of an aortic root aneurysm.

After the operation, all patients were transferred to the intensive care unit (ICU). Continuous renal replacement therapy was started for dialysis patients 6 h after the operation.

Statistical analyses. Continuous variables were expressed as mean ± standard deviations or median with interquartile and were analyzed by Student’s t-test or the Mann–Whitney U test. Categorical variables were presented as n (%) and analyzed with the chi-square or Fisher’s exact test.

A systematic literature review was conducted and identified potential predictors such as age, sex, cause, medical history, and operative procedures as predictors for prognosis in ATAAD. To reduce the influence of these confounding baseline parameters, a one-to-one propensity score matching method was applied to analyze the short-term outcomes (calipers of width 0.02 standard deviations of the logit of the propensity score), baseline characteristics and variables of interest that associated with outcomes (variables excepting for laboratory data listed in Table 1 and intro-operative variables listed in Table 3) were included in the analysis. Cumulative survival and late aortic event free rate were calculated by the Kaplan–Meier method which was performed using STATA, version 15.0 (Stata Corporation, College Station, TX), and the difference was determined by the log-rank test. The rest of statistical analyses were carried out using IBM SPSS Version 25.0 (SPSS Science, Chicago, IL, USA). A two-sided \( p < 0.05 \) was considered statistically significant.

Ethics declarations. All procedures performed in studies involving human participants were in accordance with the ethical standards of Nanjing Drum Tower Hospital of Medicine Ethics Committee for Clinical studies at which the studies were conducted (Approval number: No. BL2014004). Written informed consent was waived due to the nature of the study.

Results
Patients’ preoperative parameters and anatomical characteristics of the ATAAD lesions were shown in Table 1. Our data showed that the average age of patients in the dialysis group was similar to those in the non-dialysis group (47.1 ± 11.2 years vs. 53.1 ± 13.2 years, \( p > 0.05 \)). However, significantly more patients in the dialysis group had hypertension histories (\( p = 0.009 \)). Interestingly, no significant difference was identified in preoperative hemodynamic measurements and organ malperfusion conditions between the two groups. On the other hand, the levels of leukocyte count, haemoglobin, creatinine, and blood urea nitrogen were significantly different between the two groups. In addition, we found out a clear trend that dialysis patients were more likely to have primary entry tear in the aortic arch, even though the difference was not statistically significant.

As shown in Table 2, the leading primary cause for ESRD were hypertension (\( n = 10 \)) followed by chronic glomerulonephritis (\( n = 5 \)). The mean duration of dialysis history before the onset of ATAAD was 4.5 ± 3.5 years, and 87.5% of these patients were receiving hemodialysis (rather than peritoneal dialysis).

As shown in Table 3, operative variables like arterial cannulation sites, aortic arch surgery methods, distal surgical techniques, and cardiopulmonary bypass duration were similar between the two groups. However, dialysis patients were more likely to receive root construction, compared to patients in the non-dialysis group.

Next, we examined the early prognosis of ATAAD repair surgery in both groups (Table 4). Before propensity score matching, the 30-Day mortality rate of patients in the dialysis group was similar to the non-dialysis group (12.5% vs. 11.4%, \( p > 0.05 \)). In the dialysis group, the causes for 30-Day in-hospital death were intracranial hemorrhage (\( n = 1 \)) and multi-organ failure (\( n = 1 \)). Interestingly, the ICU and hospital stay were similar between the two groups as well as operation associated complications. Meanwhile, the drainage volume 24 h after surgery, mechanical ventilation duration, and re-intubation rate were significantly increased in the dialysis group (\( p < 0.05 \)). After propensity score matching, the 30-Day mortality remained similar between the two groups. In addition, the differences of other postoperative parameters were no longer identifiable between the two groups after propensity score matching.

105 patients (11.9%) died during the hospitalization period. The median follow-up was 29 months. 46 patients (5.9%) who were lost to follow-up and 1 patient who committed suicide 6 months after hospital discharge were identified as censored data. A total of 43 patients in the non-dialysis group and 5 patients in the dialysis group died during the follow-up period (Fig. 1). The 1-year and 3-year survival rates was significantly decreased in dialysis patients compared to non-dialysis patients (59.3 ± 14.3% vs. 96.8 ± 0.7% and 29.7 ± 16.5% vs. 90.1 ± 1.7%, respectively \( p < 0.001 \), log-rank).

Late aortic events including sudden death (\( n = 3 \)) and reoperation at a different site of the aorta (\( n = 1 \)) were identified in the dialysis group. On the other hand, fatal aortic rupture (\( n = 9 \)), sudden death (\( n = 12 \)) and
reoperation at a different site of the aorta (n = 21) were identified in the non-dialysis group. As shown in the Fig. 2, the late aortic event free survival was significantly decreased in dialysis patients compared to non-dialysis patients at both 1 and 3 years after the operation (72.5 ± 14.1% vs. 97.7 ± 0.6% and 60.4 ± 14.1% vs. 90.6 ± 1.8%, respectively p < 0.001).

**Table 1.** Comparison of preoperative variables. Values for categorical variables are given as count (percentage); values for continuous variables are given as median (interquartile range) or mean ± standard deviation. BMI body mass index, WBC white blood cell, Bun blood urea nitrogen, sCr serum creatinine, PLT platelet, ALB albumin, CRP c-reactive protein, eGFR estimated glomerular filtration rate, INR international normalized ratio, PSM propensity score matching.
Discussion

In this study, our data indicated that the preoperative parameters, including hemodynamics and organ malperfusion conditions, were similar between patients without or without dialysis. Furthermore, no significant difference of postoperative parameters as well as other short-term prognosis measurements was identified in dialysis patients after propensity score matching. However, the long-term mortality and incidence of late aortic events was significantly increased in dialysis patients compared to non-dialysis patients.

Our study indicated that only 1.8% (16/882) of all ATAAD patients were receiving dialysis treatment due to ESRD, which was similar to the 1–3% prevalence identified in other previous studies. However, the treatment

Table 2. Characteristics of the renal disease. Values for categorial variables are given as count (percentage); values for continuous variables are given as mean ± standard deviation.

| Primary cause of end-stage renal disease | Total (n = 16) |
|-----------------------------------------|---------------|
| Hypertension                            | 10 (62.5%)    |
| Chronic glomerulonephritis              | 5 (31.3%)     |
| Unknown                                 | 1 (6.3%)      |

| Type of dialysis | Total (n = 16) |
|------------------|---------------|
| Hemodialysis     | 14 (87.5%)    |
| Peritoneal       | 2 (12.5%)     |

| Type of blood access | Total (n = 16) |
|----------------------|---------------|
| Upper limb hemodialysis shunt | 13 (81.3%) |
| Superficialization of the brachial artery | 1 (6.3%) |
| Duration of dialysis (years) | 4.5 ± 3.5 |

Table 3. Comparison of operative variables. Values for categorial variables are given as count (percentage); values for continuous variables are given as median (interquartile range) or mean ± standard deviation. MVR mitral valve replacement, MVP mitral valvuloplasty, TVP tricuspid valvuloplasty, CARG coronary artery bypass graft, CPB cardiopulmonary bypass, DHCA deep hypothermic circulatory arrest, PSM propensity score matching.

| Variables                                      | Total (n = 882) | Non-dialysis (n = 866) | Dialysis (n = 16) | P Value | Non-dialysis (n = 16) | Dialysis (n = 16) | P Value |
|-----------------------------------------------|----------------|------------------------|-------------------|---------|-----------------------|-------------------|---------|
| Intro-operative variables                     |                |                        |                   |         |                       |                   |         |
| CABG (%)                                      | 51 (5.8)       | 50 (5.8)               | 1 (6.3)           | 1.000   | 2 (12.5)              | 1 (6.3)           | 1.000   |
| CPB time (min)                                | 232.3 ± 67.9   | 232.3 ± 67.6           | 235.8 ± 85.1      | 0.984   | 272.3 ± 95.3          | 235.8 ± 85.1      | 0.291   |
| Aortic cross-clamp time (min)                 | 154.0 (124.0, 194.0) | 154.0 (124.0, 194.0) | 138.0 (106.8, 194.0) | 0.374   | 171.5 ± 60.6          | 156.0 ± 63.9      | 0.366   |
| DHCA time (min)                               | 29.5 ± 12.5    | 29.5 ± 12.5            | 28.2 ± 11.9       | 0.710   | 24.3 ± 12.2           | 28.2 ± 11.9       | 0.335   |
| Cannulation                                   |                |                        |                   |         |                       |                   |         |
| Axillary artery (%)                          | 171 (19.4)     | 166 (19.2)             | 5 (31.3)          | 0.213   | 6 (37.5)              | 5 (31.3)          | 0.710   |
| Femoral artery (%)                           | 230 (26.1)     | 225 (26.0)             | 5 (31.3)          | 0.578   | 5 (31.3)              | 5 (31.3)          | 1.000   |
| Axillary + femoral artery (%)                | 442 (50.1)     | 436 (50.3)             | 6 (37.5)          | 0.309   | 5 (31.3)              | 6 (37.5)          | 1.000   |
| Root procedure                                |                |                        |                   |         |                       |                   |         |
| Bentall (%)                                   | 202 (22.9)     | 201 (23.2)             | 1 (6.3)           | 0.139   | 6 (37.5)              | 1 (6.3)           | 0.083   |
| Root reconstruction (%)                      | 641 (72.7)     | 626 (72.3)             | 15 (93.8)         | 0.085   | 10 (62.5)             | 15 (93.8)         | 0.083   |
| Valve sparing root replacement (%)           | 35 (4.0)       | 35 (4.0)               | 0 (0)             | 1.000   | 3 (18.8)              | 0 (0)             | 0.248   |
| Distal surgical technique                    |                |                        |                   |         |                       |                   |         |
| Hemi-arch replacement (%)                    | 179 (20.3)     | 175 (20.2)             | 4 (25.0)          | 0.546   | 7 (43.8)              | 4 (25.0)          | 0.264   |
| Total arch + frozen elephant trunk (%)       | 422 (47.8)     | 415 (47.9)             | 7 (43.8)          | 0.741   | 10 (62.5)             | 7 (43.8)          | 0.288   |
| Arch fenestrated stent graft (%)             | 268 (30.4)     | 263 (30.4)             | 5 (31.3)          | 1.000   | 10 (62.5)             | 5 (31.3)          | 0.288   |
for this subgroup of patients is difficult and often associates with higher morbidity, such as cerebrovascular diseases, hypertension, and diabetes. A multi-center registry study conducted in Germany reported that the incidence of primary entry tear in aortic arch was 14.5%, which was similar to the 13% (113/866) we identified in our study among non-dialysis patients. In contrast, 25% (4/16) of the dialysis patients developed a primary entry tear in aortic arch. This difference might due to the increased calcification in the aortic arch area during dialysis treatment, which might explain why intimal tears are more likely to occur in the atherosclerotic aortic arch as well.

Conflicting studies had been published about the safety of surgical repair in dialysis patients. Some previous studies identified ESRD as a major risk factor for postoperative morbidity and mortality. Liu and colleagues reported that the adjusted mortality rate in dialysis-dependent patients was 3-times higher compared to those with normal renal function. In addition, Okada et al. identified that the severe renal dysfunction was an independent risk factor for in-hospital death in non-dialysis patients. On the contrary, another retrospective study which included 960 patients suggested that although the in-hospital mortality rate was increased in dialysis patients (16% vs. 6%), no statistically difference was achieved. Similarly, no significant difference of 30-Day mortality rate was identified in our cohort between dialysis patients and non-dialysis patients. Furthermore, our results also seemed contradicting to some previous studies which suggested that the ESRD was associated

### Table 4. Comparison of postoperative variables. Values for categorical variables are given as count (percentage); values for continuous variables are given as median (interquartile range) or mean ± standard deviation. *ICU* intensive care unit, *PSM* propensity score matching.

| Variables                                | Overall cohort (n = 882) | Non-dialysis (n = 866) | Dialysis (n = 16) | P Value | Non-dialysis (n = 16) | Dialysis (n = 16) | P Value |
|------------------------------------------|-------------------------|------------------------|-------------------|---------|------------------------|-------------------|---------|
| Postoperative complications (%)          |                         |                        |                   |         |                        |                   |         |
| Re-exploration for bleeding (%)          | 33 (3.7)                | 33 (3.8)               | 0 (0)             | 1.000   | 4 (25.0)               | 0 (0)             | 0.101   |
| Dialysis (%)                             | 148 (16.8)              | 132 (15.2)             | 16 (100.0)        | < 0.001 | 8 (50.0)               | 16 (100.0)        | 0.002   |
| Stroke (%)                               | 69 (7.8)                | 68 (7.9)               | 1 (6.3)           | 1.000   | 0 (0)                  | 1 (6.3)           | 1.000   |
| Paraplegia (%)                           | 29 (3.3)                | 28 (3.2)               | 1 (6.3)           | 0.417   | 0 (0)                  | 1 (6.3)           | 1.000   |
| Re-intubation (%)                        | 37 (4.2)                | 34 (3.9)               | 3 (18.8)          | 0.026   | 12.5)                  | 18.8             | 1.000   |
| Tracheostomy (%)                         | 50 (4.1)                | 55 (4.0)               | 1 (6.3)           | 0.490   | 1 (6.3)               | 1 (6.3)           | 1.000   |
| Deep sternal wound infection (%)         | 13 (1.5)                | 12 (1.4)               | 1 (6.3)           | 0.213   | 1 (6.3)               | 1 (6.3)           | 1.000   |
| Sepsis (%)                               | 8 (0.9)                 | 8 (0.9)                | 0 (0)             | 1.000   | 1 (6.3)               | 0 (0)             | 1.000   |
| Intracranial hemorrhage (%)              | 6 (0.7)                 | 5 (0.6)                | 1 (6.3)           | 0.104   | 1 (6.3)               | 1 (6.3)           | 1.000   |
| Gastrointestinal bleeding (%)            | 4 (0.5)                 | 4 (0.5)                | 0 (0)             | 1.000   | 1 (6.3)               | 0 (0)             | 1.000   |
| Drainage volume 24 h after surgery (ml) | 520.0 (300.0, 866.5)    | 510.0 (300.0, 864.5)   | 680.0 (602.5, 1042.5) | 0.033   | 520.0 (345.0, 835.0)   | 680.0 (602.5, 1042.5) | 0.051   |
| Ventilation time (hour)                  | 17.0 (11.0, 43.0)       | 17.0 (11.0, 43.0)      | 33.0 (14.6, 60.6) | 0.046   | 16.5 (16.8, 146.8)    | 33.0 (14.6, 60.6)  | 0.269   |
| ICU Stay time (day)                      | 4.0 (3.0, 7.0)          | 4.0 (3.0, 7.0)         | 6.5 (4.3, 9.0)    | 0.083   | 8.0 (6.0, 12.0)        | 6.5 (4.3, 9.0)    | 0.196   |
| Hospital stay time (day)                 | 20.9 ± 12.1             | 21.0 ± 12.2            | 18.4 ± 11.5       | 0.279   | 27.5 (10.8, 35.8)      | 17.5 (9.3, 21.3)  | 0.086   |
| 30-Day mortality (%)                    | 101 (11.5)              | 99 (11.4)              | 2 (12.5)          | 0.704   | 2 (12.5)              | 2 (12.5)          | 1.000   |

**Figure 1.** Kaplan–Meier curves for overall cumulative survival of dialysis and non-dialysis patients suffering from acute type A aortic dissection.
with increasing postoperative complications\textsuperscript{16,17}. We hypothesized the relatively improved short-term prognosis we observed in this study was due to the improvement of surgical as well as critical care techniques and more careful matching of baseline characteristics.

A dilated aorta is believed to be associated with worse long-term prognosis of ATAAD. However, our clinical experience suggests that extended aortic replacement can be especially dangerous for dialysis patients due to the increased operative invasiveness and prolonged operation time. Therefore, we suggest that the extended aortic replacement in dialysis patients should be avoided unless the clear identification of expanded lesions on imaging results.

It has been well known in the field that the control of hypertension is critical to manage patients with residual aneurysms\textsuperscript{18}. All dialysis patients in our study had hypertension, compared to the 70\% identified among non-dialysis patients. Previous studies have shown the efficacy of beta-blocking agents on prevention of aortic dissection and dilatation in Marfan syndrome patients\textsuperscript{19}. Similarly, our previous study also suggested that regular beta-blockers treatment after discharge was associated with decreased long-term mortality in ATAAD patients who received aortic dissection repair surgery\textsuperscript{20}. Considering the fact that the renin-angiotensin system was more activated in ESRD due to the hemodynamic changes, beta-blockers seemed to be more beneficial in such group of patients. For dialysis patients with hypertension, strong consideration should be given to the prescription of beta-blockers after aortic dissection repair surgery.

In addition, one of our previous studies showed that the concomitant hypertension identified upon hospital administration was an independent risk factor for long-term mortality in ATAAD patients\textsuperscript{20}. These observations indicated that strict medication adherence as well as blood pressure control after discharge is critical in the management of patients who received aortic dissection surgery repair, especially for dialysis patients.

In summary, these results indicated that the ATAAD repair surgery was relatively safe in dialysis patients but closer follow-up should be planned.

**Limitations**

This study had some limitations. Firstly, this was a retrospective study conducted in a single center with limited dialysis patients. A multi-center study with a larger cohort is needed to validate our findings in future. Secondly, our surgical technique had evolved over the study period which might influence the results. Finally, the result of this study should be interpreted with caution due to limited follow-up period and incomplete demographic data from some patients.

**Conclusion**

Our study indicated that the short-term outcomes for dialysis patients who received conventional ATAAD repair surgery were acceptable. However, these patients were associated with a worse long-term prognosis. These results reemphasized the need for close follow-up examination and precautions should be made for late aortic events in dialysis patients who received ATAAD repair surgery. Further prospective multicenter studies aim to identify approaches to reduce late complications are required.

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**Author contributions**
D.W. and Z.W. conceived and designed the experiments; P.G., L.L., M.G., and C.C. collected the samples; Z.W. and L.Z. analyzed the data; Z.W., P.G., and L.L. wrote the paper. All authors reviewed the manuscript before submission.

**Competing interests**
The authors declare no competing interests.

**Additional information**
Correspondence and requests for materials should be addressed to D.W.

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