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ORIGINAL RESEARCH

# One-Year Functional Outcome of Patients After Surgery for Acute Stanford Type A Aortic Dissection

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**BACKGROUND:** Our aim was to report the functional outcome of Stanford type A aortic dissection (TAAD) after 1 year as well as morbidity and mortality.

**METHODS AND RESULTS:** This is a retrospective analysis including 642 patients with TAAD from January 2005 to December 2021. Mean age at TAAD was 62 years (95% CI, 61–63), and 30% of the population were women. One year after surgery for TAAD, 75% of patients were living at home with New York Heart Association functional class I. No patients were observed with New York Heart Association functional class IV. Less than 2% resided in an assisted-living facility. Eighty-five percent of nonretired patients had returned to work. Two hundred twelve (33%) patients were retired after 1 year at a mean age of 73 years (95% CI, 72–74). Stroke (defined as any kind of neurological symptoms) occurred in 148 (23%) patients and was the cause of death in 33 patients. Of the remaining patients with stroke, 115 (30%) had no residual limitations 1 year after TAAD. The cross-clamp time was significantly higher in patients with stroke (98 minutes [95% CI, 94.0–101.1] in patients without stroke versus 106 minutes [95% CI, 98.5–114.1] in patients with stroke; $P$=0.026). Sixty-nine percent of patients with stroke lived at home, 28% lived at home with support, and 3% lived in an assisted-living facility. One year after stroke, 77% of the patients achieved a modified Rankin Scale score ≤2, whereas no patient had a modified Rankin Scale score of 5. There was no significant correlation between sex and recovery rate ($P$=0.48). However, experiencing a stroke significantly increased the likelihood of residing in an assisted-living facility or receiving support at home 1 year after TAAD (odds ratio, 9.46 [95% CI, 5.06–17.70]; $P$<0.001). Thirty-day mortality was 11.8%, and 92 patients (14%) died within the first year after TAAD. There was no significant sex difference in mortality ($P$=0.101).

**CONCLUSIONS:** One year after surgery for Stanford acute type A aortic dissection, almost 3 out of 4 patients lived unassisted at home. Stroke survivors have a favorable outcome, with the majority having mild or no residual neurological deficits at 1 year.

**Key Words:** aorta ■ aortic dissection ■ functional outcome ■ stroke

Stanford type A aortic dissection (TAAD) is a life-threatening medical condition with high morbidity and mortality.[1–4] It remains a challenging clinical emergency although first described 200 years ago.[5] Although mortality has decreased over time, little is known about the functional outcome of patients after TAAD in a contemporary cohort of patients. Mortality is an important marker of the quality of surgical care; however, it has little value in describing quality of life after the event. As life expectancy continues to increase, more and more older patients will be faced with whether to undergo major surgery

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## CLINICAL PERSPECTIVE

### What Is New?

- This study highlights that almost 75% of patients undergoing surgery for Stanford type A aortic dissection are living independently at home within 1 year, with 85% of nonretired patients returning to work.
- Stroke survivors demonstrate favorable outcomes 1 year after surgery, with the majority exhibiting mild or no residual neurological deficits.

### What Are the Clinical Implications?

- Surgical treatment of Stanford type A aortic dissection has favorable functional outcomes, underscoring its efficacy despite the severity of the condition.
- These findings support counseling patients on long-term expectations and tailoring rehabilitation strategies to improve quality of life.

### Nonstandard Abbreviations and Acronyms

| | |
|---|---|
| **mRS** | modified Rankin Scale |
| **TAAD** | Stanford type A aortic dissection |
| **X-clamp** | cross-clamp |

when dissection occurs. Knowledge about the functional outcome of these patients is crucial for shared decision-making of patients and surgeons. We aimed to report the functional outcome of patients with TAAD after 1 year as well as morbidity and mortality after surgical treatment.

## METHODS

### Ethics Statement

The study was approved by the local ethics committee (Swiss Association of Research Ethics Committees [swissethics]) (approval number 2020-01149). Informed consent was waived due to the retrospective nature of this chart-based review.

### Statistical Analysis

Data are presented as mean with 95% CI or median and interquartile range (IQR), depending on data distribution. In addition to descriptive statistics, a Kaplan-Meier survival analysis was performed at the 1-year follow-up.

The null hypothesis of our study was that there is no significant difference in the 1-year functional outcomes of patients after surgery for acute TAAD. We aimed to test this hypothesis by comparing various functional, neurological, and social outcomes within this patient population.

Multinomial logistic regression was used to examine the relationship between the categorical outcomes (cardiac, neurological, and social outcomes). The 6 patients with overlapping outcomes were assigned as follows: 5 patients were categorized into the neurological outcome group, and 1 was categorized into the cardiac outcome group. Excluding these 6 patients from the analysis did not alter the results.

Analysis was performed with Stata version 16 (StataCorp, College Station, TX). For the contingency analysis, we used the Fisher exact test, a *t* test, or ANOVA. A $P$ value $<0.05$ was considered statistically significant.

### Patient Selection and Data Collection

All patients who suffered from TAAD between January 2005 and December 2021 seen at this institution were included in this observational, retrospective single-center study. All of our patients with TAAD are seen postoperatively in our clinic at 3 months and again at 1 year for a computed tomography angiography. After that, we generally follow up on our patients with TAAD for the rest of their lives. The data were obtained from these clinic records. An observational design was used conforming to the STROBE (Strengthening the Reporting of Observational studies in Epidemiology) statement.[6]

All data were gathered in a standardized database using the Research Electronic Data Capture system.

Follow-up at 12 months was 90% complete. Patient characteristics, procedural data, and outcomes are shown in the Table.

### Definitions

Functional outcomes were assessed in 3 categories: cardiac outcomes, neurological outcomes in patients with stroke, and social outcomes. Each category was evaluated using specific variables. Cardiac outcomes were measured using New York Heart Association (NYHA) classification, and neurological outcomes (in patients with stroke) were assessed with the modified Rankin Scale (mRS). Social outcomes were evaluated based on the living environment and employment status (Figure 1).

Regrettably, a universally accepted definition of stroke is currently lacking. To ensure precision, we delineated the concept of stroke twice considering the recent recommendations.[7–9] Initially, stroke was defined as the compromise in any neurological function, encompassing conditions such as spinal ischemia and delirium. Acknowledging the expansive scope of this definition, we augmented it with a more precise classification where we only included CT/magnetic resonance imaging

**Table. Baseline Characteristic of the Study Population**

| Baseline characteristics | Value (N=642) |
|---|---|
| Age at TAAD, y | 62 (61–63) |
| Female sex | 192/642 (30%) |
| Obesity | 129/605 (21%) |
| Hypertension | 410/561 (73%) |
| Diabetes | 21/559 (4%) |
| Dyslipidemia | 154/478 (32%) |
| Peripheral arterial disease | 197/588 (34%) |
| COPD | 48/545 (9%) |
| Previous cardiac surgery | 27/612 (4%) |
| Mean EF | 58% (58%–59%) |
| X-clamp time, min | 99.6 (96.3–102.9) |
| ACP time, min | 31.2 (29.8–32.5) |
| Sternotomy only | 6 |
| Ascending aortic replacement | 636 |
| Bentall procedures | 232 |
| Partial aortic arch replacement | 573 |
| Total aortic arch replacement | 42 |
| Mortality at 30 d after TAAD | 76 (12%) |
| Mortality at 1 y after TAAD | 92 (14%) |
| Lost to follow-up | 65 (10%) |

Data are presented as mean (95% CI) or n (%). ACP indicates antegrade cerebral perfusion; COPD, chronic obstructive pulmonary disease; EF, ejection fraction; TAAD, Stanford type A aortic dissection; and X-clamp, cross-clamp.

(MRI)-confirmed stroke. This classification included individuals diagnosed with stroke, verified through imaging techniques such as CT or MRI scans. There were patients with pathological head CT/MRI results, but their primary clinical issue was spinal ischemia. We decided to include these patients in this subpopulation as well.

As mentioned, the mRS score was evaluated in all patients with stroke. This widely used clinical tool measures functional disability and dependence in individuals following a stroke or other neurological conditions. The scale ranges from 0 (no symptoms) to 6 (death), with each level indicating varying degrees of disability. A lower score on the mRS reflects better functional independence, whereas higher scores indicate greater disability or dependence on others for daily activities.

Additionally, all patients with neurological deficits were categorized into transient neurological deficits and persistent neurological deficits. Transient neurological deficits were defined as complete recovery within the first 7 days, whereas patients who did not achieve full recovery within this period were classified as having persistent neurological deficits.

All patients with neurological deficits were evaluated by neurologists. If hemodynamically stable, patients received a CT brain scan and, depending on the results, an MRI of the brain after removal of the temporary pacemaker cables. In cases of embolic stroke, an embolectomy was performed as quickly as possible. Depending on the stroke's severity, patients were preferably referred to inpatient neurological rehabilitation rather than cardiac rehabilitation once they were deemed stable. According to guidelines, the standard care after surgery involves discharge to home with outpatient cardiac rehabilitation or inpatient cardiac rehabilitation.[10,11]

## Data Access and Responsibility

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary material.

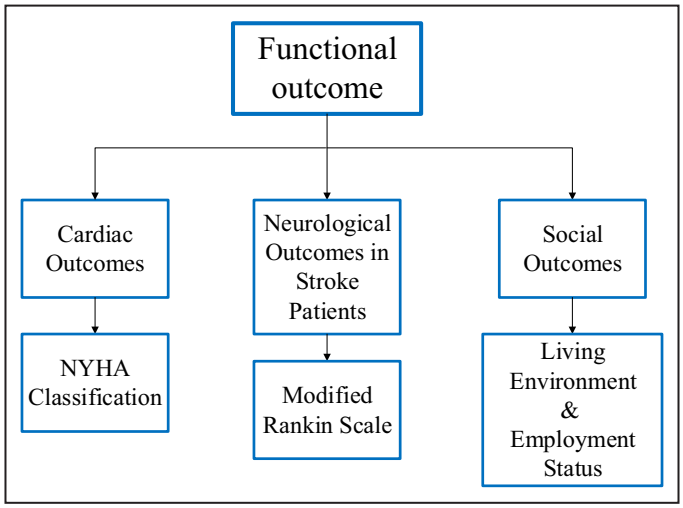


**Figure 1. Chart of the assessment of functional outcomes.**
Functional outcomes were evaluated in 3 categories: cardiac outcomes, neurological outcomes in patients with stroke, and social outcomes. Each category was assessed using specific variables. NYHA indicates New York Heart Association.

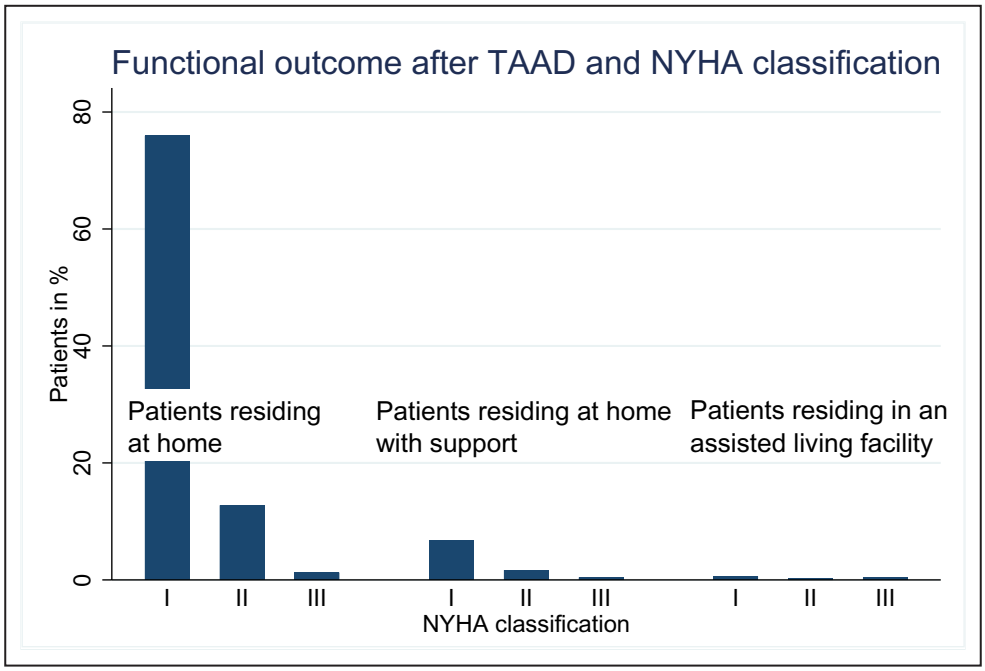


**Figure 2. Functional outcome after TAAD based on NYHA classification.**
The bar chart illustrates the distribution of patients represented in percentage according to their functional outcome following TAAD. NYHA indicates New York Heart Association; and TAAD, Stanford type A aortic dissection.

# RESULTS

## Overall

Overall, 642 patients presented with TAAD (mean age at TAAD, 62.1 years [95% CI, 61.1–63.1]; 30% female patients). In total, 636 ascending aortic replacements, 232 Bentall procedures, 573 partial aortic arch replacements, and 42 total aortic arch replacements were performed. Six patients died intraoperatively following sternotomy and did not receive any aortic procedure.

Mean cross-clamp (X-clamp) time was 99.6 minutes (95% CI, 96.3–102.9), and mean antegrade cerebral perfusion time was 31.2 minutes (95% CI, 29.8–32.5) (Table). Loss to follow-up was 10% (65 patients).

## Functional Outcome

One year following TAAD, 75% of patients were residing at home with NYHA class I classification (Figure 2). Notably, no patients were classified as NYHA class IV. Furthermore, <2% of the patients were residing in an assisted-living facility.

In relation to functional capacity, among the nonretired patients (267 patients documented), 226 (85%) returned to work 1 year after TAAD. The workload of these 226 patients was 75.9% (95% CI, 71.2–80.5), with 181 (80%) of them returning to work at full capacity (100% workload). Among the patient cohort, 212 individuals (44%) transitioned or were retired after 1 year of TAAD, with a mean age of 73.0 years (95% CI, 72.2–74.0).

## Stroke and Functional Outcome

Stroke occurred in 148 patients (23%) with TAAD, and of these, 33 patients died (85% in <30 days). Of the 148 patients, 26 (17%) presented with preoperative neurological disabilities, and an additional 118 (80%) exhibited intraoperative neurological complications, which included early postoperative effects such as any compromise in neurological function. Notably, 4 patients (3%), initially free from any postoperative neurological impairments, later encountered a postoperative stroke. Pericardial effusion in patients with neurological disability was present in 60 patients (41%), and 25 (17%) of these patients were hemodynamically impaired.

Out of 148 patients, 29 (20%) had temporal neurological deficits. Of these, all but 2 patients were living at home independently, representing 93% of the total. One of the 2 exceptions was a patient who had previously resided in an assisted-living facility before developing TAAD, and the other was a patient who died during follow-up due to septic shock from an esophageal fistula and aortic prosthetic infection.

Among the 115 patients who survived a stroke 1 year after TAAD, 30% showed no residual limitations. In patients with stroke, 69% lived at home, 28% lived at

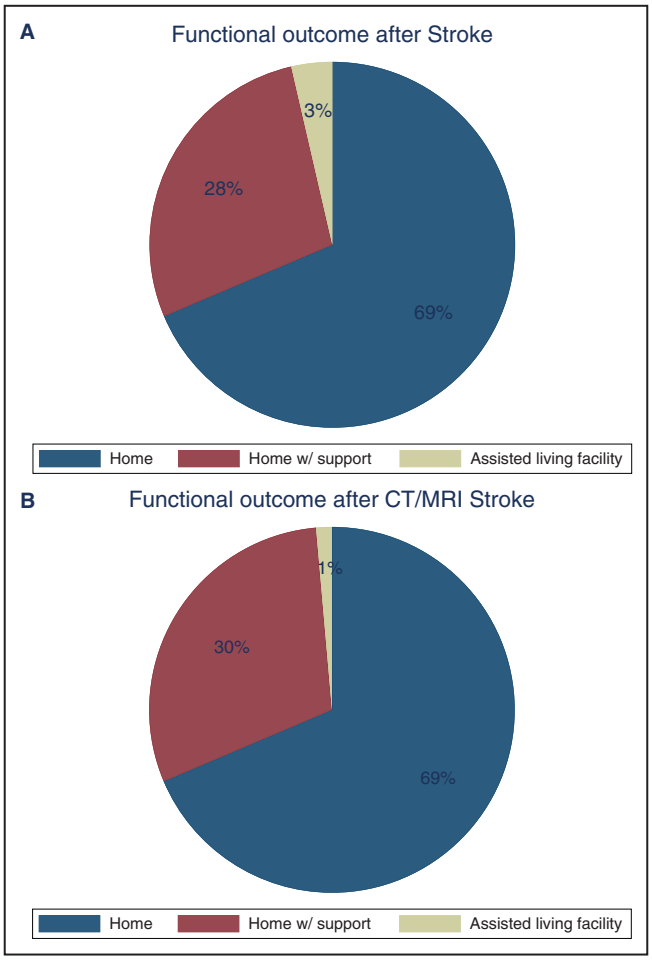


**Figure 3. Distribution of functional outcome after stroke.**
**A**, The pie chart illustrates the distribution of functional outcomes among individuals who have experienced a stroke. Each segment of the pie chart corresponds to the functional outcomes 1 year after TAAD, depicting the percentage of patients residing independently at home, those receiving support at home, or those residing in an assisted-living facility. **B**, Distribution of functional outcome after CT/MRI-confirmed stroke. CT indicates computed tomography; MRI, magnetic resonance imaging; and TAAD, Stanford type A aortic dissection.

home with support, and 3% lived in an assisted-living facility (Figure 3A).

There was no significant correlation between sex and recovery rate in patients with stroke (odds ratio [OR] for women, 0.81 [95% CI, 0.33–2.00]; *P*=0.635).

The X-clamp time was significantly higher in patients with stroke (97.6 minutes [95% CI, 94.0–101.1] in patients without stroke versus 106.3 minutes [95% CI, 98.5–114.1] in patients with stroke; *P*=0.026; OR [logistic regression], 1.00 [95% CI, 1.00–1.01]; *P*=0.027). However, the X-clamp time did not demonstrate a statistically significant difference in terms of residing in an assisted-living facility or receiving support at home compared with living independently without support (96.9 minutes [95% CI, 93.3–100.4] in patients living at home without support versus 100.8 minutes [95% CI, 98.7–113.9]; *P*=0.488).

In addition, there was no difference in antegrade cerebral perfusion time between patients with or without stroke (30.5 minutes [95% CI, 29.0–32.0] for patients without stroke compared with 33.2 minutes [95% CI, 30.3–36.2]; *P*=0.086). Similarly, this holds true for antegrade cerebral perfusion time and patients living at home with support or living in an assisted-living facility compared with living independently without support (30.3 minutes [95% CI, 28.8–31.8] for patients living at home without support versus 33.2 minutes [95% CI, 28.1–38.4]; *P*=0.216).

However, history of stroke was a significant risk factor for being in an assisted-living facility or at home

with support 1 year post-TAAD (OR, 9.46 [95% CI, 5.06–17.70]; *P*<0.001).

Among the 115 patients with stroke, 35 (30.4%) had an mRS score of 0, 27 (23.5%) had an mRS score of 1, 26 (22.6%) had an mRS score of 2, 17 (14.8%) had an mRS score of 3, and 10 (8.7%) had an mRS score of 4 (Figure 4A). More than 60% of the patients living at home had an mRS score between 0 and 2. One patient with an mRS score of 4, who was paraplegic, lived independently at home. Another patient, with an mRS score of 0, moved to an assisted-living facility after TAAD repair due to bilateral coxarthrosis (Figure S1). Having a stroke was a significant risk factor for death (OR, 1.80 [95% CI, 1.08–2.96]; *P*=0.014).

In our multiregression analysis (Fine-Gray analysis with competing against death), the mRS scores showed no effect of either assisted-living situation or the severity of NYHA class (hazard ratio [HR] of mRS score for the NYHA class >2 model, 0.78 [95% CI, 0.58–1.04]; *P*=0.093; and mRS score HR for the assisted-living situation model, 1.70 [95% CI, 0.78–3.70]; *P*=0.183).

## CT- or MRI-Confirmed Stroke and Functional Outcome

Ninety-seven patients (15%) had CT- or MRI-confirmed stroke, of whom 30 patients died (53% [16 patients] died in <30 days). Of the remaining 67 patients, 30% had no residual limitations at 1 year after TAAD. In this subpopulation of 97 patients, 14 (14%) presented with preoperative stroke, and 79 (81%) experienced an intraoperative stroke. Additionally, 4 patients (4%) who were initially free from postoperative neurological impairments later encountered a postoperative stroke. Pericardial effusion was present in 30 patients (31%), of whom 9 (9%) were hemodynamically impaired.

In patients with stroke, 69% lived at home, 30% lived at home with support, and 1% lived in an assisted-living facility (Figure 3B). There was no significant correlation between sex and recovery rate in patients with CT/MRI-confirmed stroke (OR for women, 1.02 [95% CI, 0.32–3.19]; *P*=0.979). The X-clamp time was significantly higher in patients with CT/MRI-confirmed stroke (98.1 minutes [95% CI, 94.7–101.5] in patients without stroke versus 107.8 minutes [95% CI, 97.7–117.9] in patients with stroke; *P*=0.036; OR [logistic regression], 1.01 [95% CI, 1.00–1.01]; *P*=0.038). There was a significant difference in antegrade cerebral perfusion time between patients with or without CT/MRI-confirmed stroke (30.5 minutes [95% CI, 29.1–31.9] for patients without stroke compared with 34.7 minutes [95% CI, 30.8–38.6]; *P*=0.027; OR [logistic regression], 1.01 [95% CI, 1.00–1.02]; *P*=0.031).

The history of stroke was a significant risk factor for being in an assisted-living facility or at home with support 1 year post-TAAD (OR, 5.5 [95% CI, 2.93–10.34]; *P*<0.001).

Among the 67 patients with CT/MRI-confirmed stroke, 20 (29.9%) had an mRS score of 0, 19 (28.4%) had an mRS score of 1, 15 (22.4%) had an mRS score of 2, 7 (10.4%) had an mRS score of 3, and 6 (9%) had an mRS score of 4 (Figure 4B).

Having a CT/MRI-confirmed stroke was a significant risk factor for death (OR, 3.02 [95% CI, 1.75–5.14]; *P*<0.001).

## Mortality

Ten patients died during the surgery (6 patients following sternotomy, 2 after Bentall and partial arch procedures, 1 after ascending and partial arch replacement, and 1 after ascending and total arch replacement). The 30-day mortality was 12% (76 patients), and 1-year mortality was 14% (92 patients). There was no significant sex difference in mortality (*P*=0.101) (Figure 5). Furthermore, age was not a statistically significant risk factor (*P*=0.221) (Figure 6).

## Multinominal Logistic Regression Analysis of Clinical Outcomes

The multinomial logistic regression showed that age is significantly associated with failure in cardiac outcomes (relative risk ratio, 1.03; *P*=0.042) and death (relative risk ratio, 1.04; *P*=0.001), with a relative risk increase of 2.68% and 4.39%, respectively. Additionally, X-clamp time is significantly associated with death (relative risk ratio, 1.01; *P*=0.001), indicating a 1.17% increase in relative risk per minute. Other variables, including sex, hypertension, diabetes, and tobacco use, were not significant. No significant associations were found for the neurological or social outcome groups.

# DISCUSSION

Aortic dissection is a severe and life-threatening condition requiring immediate medical attention. The functional outcome of patients following TAAD surgical repair is crucial for their overall quality of life and long-term prognosis.

In this study, we demonstrated that patients who had experienced perioperative stroke showed significant improvement over time. One year after the occurrence of a TAAD, one-third had no residual limitations, and more than half of the patients achieved an mRS score of 0 or 1, whereas only 20% of the patients had an mRS score of 3 or 4. Furthermore, 69% of the patients with stroke lived at home, 28% lived at home with support, and only 3% lived in an assisted-living facility. Therefore, stroke alone should not preclude patients from undergoing surgery in case of TAAD.[12]

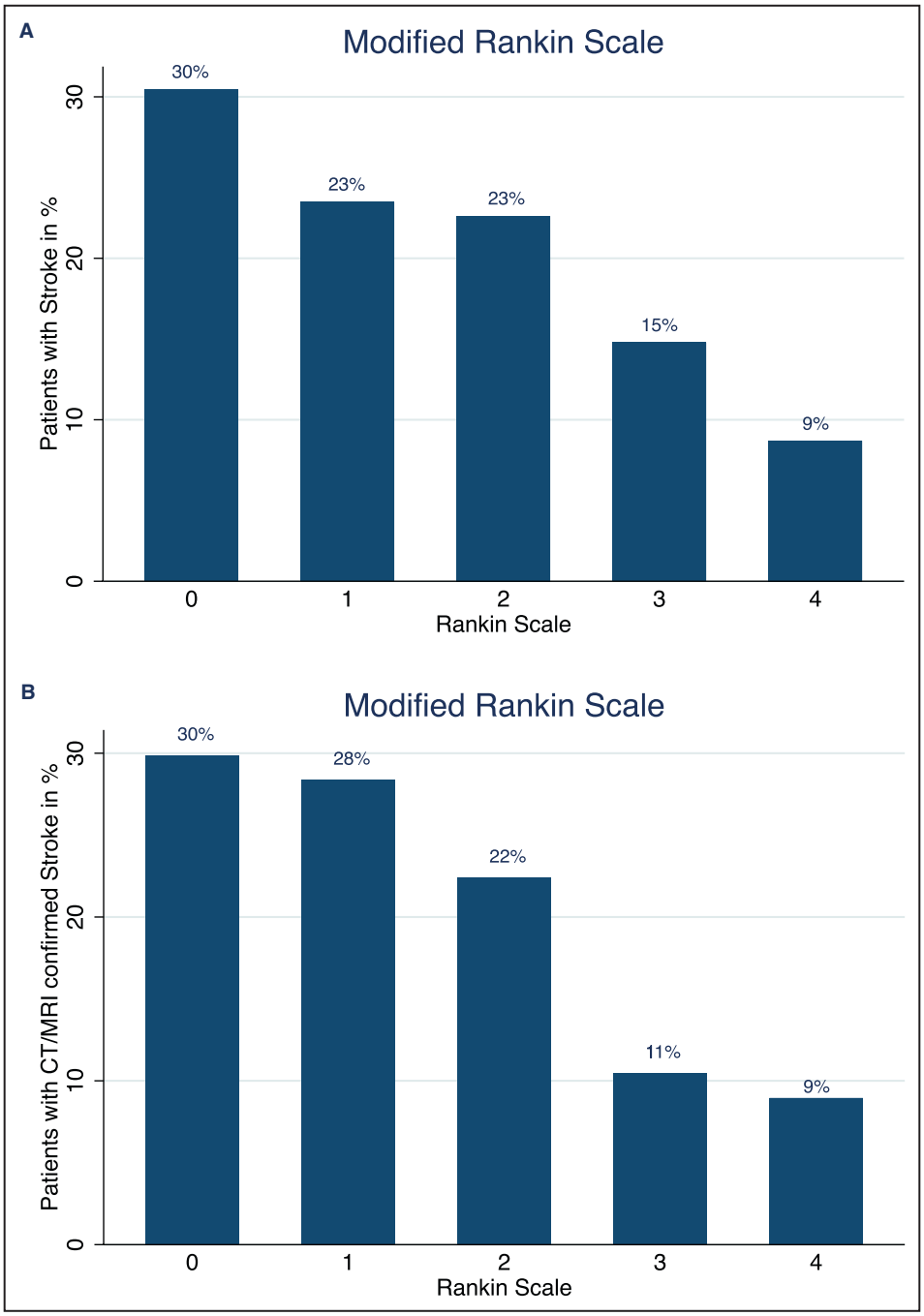


**Figure 4. Distribution of modified Rankin Scale scores 1 year after TAAD in patients with stroke.**

**A**, The bar chart presents the percentage distribution of patients with stroke on the *y* axis, categorized by their modified Rankin Scale score on the *x* axis 1 year after experiencing TAAD. The modified Rankin Scale is used to assess functional outcomes and disability levels, with lower scores indicating better functional status. **B**, Distribution of modified Rankin Scale scores 1 year after TAAD in patients with CT/MRI-confirmed stroke. CT indicates computed tomography; MRI, magnetic resonance imaging; and TAAD, Stanford type A aortic dissection.

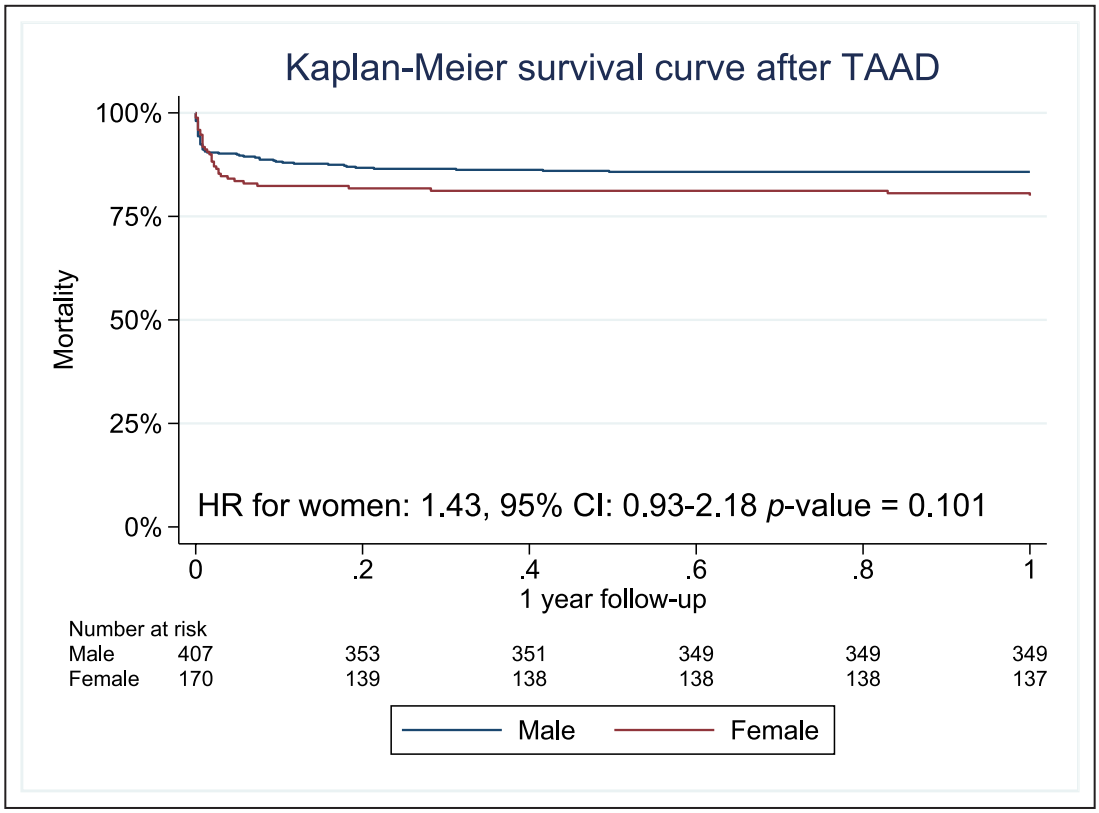


**Figure 5. Kaplan-Meier survival curve for TAAD stratified by sex.**
The Kaplan-Meier survival curve depicts the survival outcomes following TAAD over the 1-year follow-up. The blue line represents male patients, whiles the red line represents female patients. The *x* axis displays the survival time, and the *y* axis illustrates the proportion of patients surviving at each time point. HR indicates hazard ratio; and TAAD, Stanford type A aortic dissection.

However, a significant correlation was observed between experiencing a stroke and residing either at home with support or in an assisted-living facility. This correlation remains statistically significant, even when considering that patients with stroke were confirmed through CT/MRI.

Stroke occurred in 148 patients (23%), which is high in comparison with other studies.[13–19] This high incidence can be attributed to our inclusion criteria, which encompassed all patients with any kind of neurological disability. Notably, 17% of the patients already exhibited neurological disabilities preoperatively. Our broad definition aimed to include a wide range of neurological conditions, such as peripheral nerve lesions, central retinal artery occlusion, and cases with unclear neurological status without pathological CT/MRI findings. This comprehensive approach explains the relatively high incidence of neurological deficits in our study.

The stroke rate is 15% when only analyzing patients with stroke confirmed by imaging. This is in line with previously reported in-hospital neurologic deficits (NORCAAD [Nordic Consortium for Acute Type A Aortic Dissection] 15.7% and IRAD [International Registry of Acute Aortic Dissection] 22.7%).[15,20] Interestingly, there was no difference in the functional outcome no matter how strict the definition of stroke was. This emphasizes the potential for recovery. Cardiac ischemic time was increased among patients with stroke. The same results were found in the NORCAAD registry.[15] Similar to this study, this can be attributed to the more extensive dissection and surgical interventions performed on these patients, consequently elevating the risk of stroke.

To date, no study has examined the workload of patients following TAAD. In our population, 85% of the nonretired patients had returned to work, indicating that a significant number of patients are able to resume work after experiencing this severe condition. This corresponds with the NYHA classification, with 75% of patients at NYHA class I and no patients at NYHA class IV. In the study group from Brisbane, 90% of the surviving patients had NYHA class I to II, which is in line with our findings.[21] In their study, they completed the EQ-5D form for a small number of patients, revealing that 48% of these individuals were categorized as being in perfect health. This is consistent with the notion of a high quality of life among survivors.

The outcomes of TAAD, even with surgical repair, are associated with high morbidity and mortality. Several

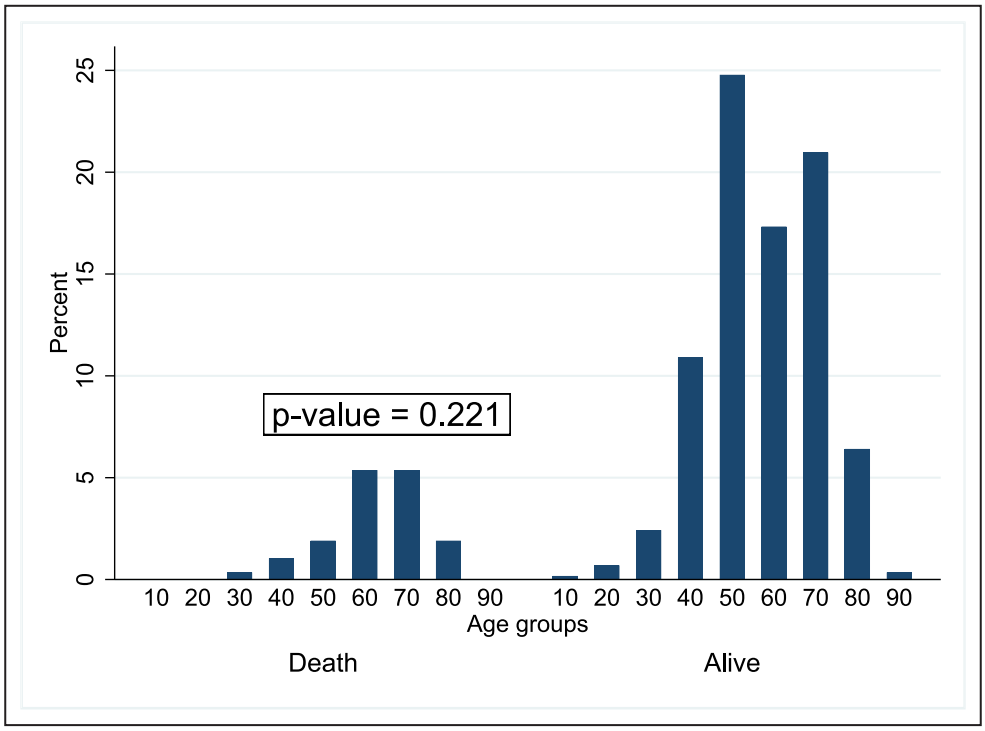


**Figure 6. Distribution of age groups among patients with TAAD, stratified by survival status.** The bar chart presents the percentage distribution of patients with TAAD on the *y* axis, categorized into different age groups on the *x* axis. The bars are further divided into 2 groups, Death and Alive, representing the survival status of patients. TAAD indicates Stanford type A aortic dissection.

registries report in-hospital mortality rates for TAAD of 12% to 25% (Japan Registry of Aortic Dissection (JRAD) 12%, IRAD 18%, and Spanish Registry of Acute Aortic Syndrome (RESA II) 25%).[22–24] In our study population, the 30-day mortality was 12%, and the 1-year mortality was 14%. These numbers are excellent and favorably compare with findings from other single-center series, where 30-day mortality ranged from 9% to 45% and 1-year mortality ranged from 10% to 24%.[17–19,21,25–28]

## LIMITATIONS

This study presents a retrospective observational analysis and is therefore subject to all limitations of such a study design.

## CONCLUSIONS

One year after surgery for acute type A aortic dissection, almost 3 out of 4 patients live unassisted at home. Stroke survivors have a favorable outcome, with the majority having mild or no residual neurological deficits at 1 year. Nevertheless, experiencing stroke is a risk factor for living in an assisted-living facility 1 year after the event. There were no sex differences in suffering from a stroke, living in an assisted-living facility, or mortality.

## ARTICLE INFORMATION

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None.

### Disclosures

None.

### Supplemental Material

Figure S1

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