Acute Type A Aortic Dissection in Adolescents and Young Adults under 30 Years of Age: Demographics, Etiology and Postoperative Outcomes of 139 cases

Maximilian Luehr[1], Murat Yildiz[2], Wei-Guo Ma[3], Roland Heck[4], Andreas Polycarpou[5], Arminder Jassar[6], Maximilian Kreibich[7], Daniel-Sebastian Dohle[8], Gabriel Weiss[9], Christian Hagl[10,11], Filip Rega[12], Thomas Schachner[13], Andreas Martens[14], Alessandro Della Corte[15], Hiroaki Osada[16], Li-Zhong Sun[3], Konstantinos Tsagakis[17], Florian Schoenhoff[2]

[1]Department of Cardiothoracic Surgery, HeartCenter, University of Cologne, Cologne, Germany
[2]Department of Cardiovascular Surgery, University Hospital Bern, University of Bern, Switzerland
[3]Anzhen Aortic Surgery, Capital Medical University, Beijing, China
[4]Department of Cardiothoracic and Vascular Surgery, German Heart Center Berlin, Germany
[5]Department of Cardiovascular Surgery, Mayo Clinic, Rochester, MN,USA
[6]Division of Cardiac Surgery, Massachusetts General Hospital, Boston,MA,USA
[7]Department of Cardiovascular Surgery, Faculty of Medicine, University Heart Center Freiburg—Bad Krozingen, Germany
[8]Department of Cardiothoracic and Vascular Surgery, University Hospital of Johannes Gutenberg University Mainz, Mainz, Germany
[9]Department of Cardiovascular Surgery, Clinic Floridsdorf, Vienna, Austria
[10]Department of Cardiac Surgery, LMU University Hospital, Munich, Germany
[11]German Centre for Cardiovascular Research(DZHK),partner site Munich Heart Alliance, Munich, Germany
[12]Department of Thoracic Surgery,University Hospital Gasthuisberg, Leuven, Belgium
[13]Department for Operative Medicine, University Clinic for Cardiac Surgery, Medical University Innsbruck, Innsbruck, Austria
[14]Department of Cardiothoracic, Transplantation and Vascular Surgery, Hannover Medical School, Hannover, Germany
[15]Department of Translational Medical Sciences, University of Campania "L.Vanvitelli", Naples, Italy
[16]Department of Cardiovascular Surgery, Graduate School of Medicine, Kyoto University, Kyoto, Japan
[17]Department of Thoracic and Cardiovascular Surgery, West-German Heart and Vascular Center, University Hospital Essen, Essen, Germany

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Corresponding author:
Maximilian Luehr, MD, PhD
Cardiothoracic Surgery
University of Cologne
Kerpener Str.62, 50937, Cologne, Germany
Phone:+49(0)22147832487
Fax:+49(0)22147832648
E-mail: maximilian.luehr@uk-koeln.de

KEY QUESTION

What is the prevalence and etiology of acute type A aortic dissection (AADA) in surgical patients ≤30years?

KEY FINDINGS

The overall prevalence in 7914 consecutive cases was 1.8%(n=139); Connective tissue disease (36.7%) and arterial hypertension (33.1%) were the two most frequent risk factors for AADA,while 9.4% of the cohort presented with a positive family history.

TAKE-HOME MESSAGE

The etiology of AADA is likely to be associated with connective tissue disease or arterial hypertension in patients ≤30years; open surgery may be performed with good short- and excellent long-term survival in these patients.

KEYWORDS: acute aortic dissection; aortic surgery; connective tissue disease; Marfan syndrome; Loeys-Dietz syndrome; Turner syndrome; genetic testing

ABSTRACT

Background: The prevalence and etiology of acute aortic dissection type A in patients ≤30 years is unknown. The aims of this clinical study were to determine the prevalence and potential etiology of acute aortic dissection type A in surgically treated patients ≤30 years and to evaluate the respective postoperative outcomes in this selective group of patients in a large multi-centre study.

Methods: Retrospective data collection was performed at the 16 participating international aortic institutions. All patients ≤30years at the time of dissection onset were included. The postoperative results were analysed with regard to connective tissue disease.

Results: The overall prevalence of acute aortic dissection type A ≤30years was 1.8% (139 out of 7914 patients), including 51(36.7%) patients who were retrospectively diagnosed with connective tissue disease. Cumulative postoperative mortality was 8.6%, 2.2% and 1.4%, respectively. Actuarial survival was 80% at 10 years postoperatively. Non- connective tissue disease patients (n=88) had a significantly higher incidence of arterial hypertension (46.6%vs.9.8%;p<0.001) while acute aortic dissection type A affected the aortic root (p<0.001) and arch (p=0.029) significantly more often in the connective tissue disease group. A positive family history of aortic disease was present in 9.4% of the study cohort(n=13).

Conclusions: The prevalence of acute aortic dissection type A in surgically treated patients ≤30 years is less than 2% with connective tissue disease and arterial hypertension as the two most prevalent triggers of acute aortic dissection type A. Open surgery may be performed with good early results and excellent mid- to long-term outcomes.

INTRODUCTION

Acute aortic dissection type A (AADA) remains associated with high mortality rates if diagnosed too late or managed only medically[1–4]. Since the early beginnings of cardiovascular surgery in the 1960s until today, the gold standard to address and potentially cure this dreadful disease is open surgery[6]. Over the last decades, the available surgical techniques and intraoperative management strategies evolved dramatically, comprising selective cerebral and other organ perfusion strategies, application of more moderate body core temperatures and the use of hybrid prostheses to reduce the duration and total number of surgeries[7,8]. These developments allowed for significant reduction of the associated mortality and morbidity rates, but still, AADA surgery may still result in postoperative mortality rates of 5% to 28%, depending on the preoperative clinical condition and the experience of the surgical team [1,2,5,7,9]. Prevention of AADA by routine follow-up imaging to allow for timely surgery with regard to aortic diameter progression plays a key role in patients with known aneurysm. However, AADA often occurs in the 6th and 7th life decade in individuals with undiagnosed arterial hypertension and lower aortic diameters who are believed to be otherwise healthy[10].

In the very young (≤30 years) the occurrence of AADA is rarely seen and, in general, is believed to be related to connective tissue disease (CTD), aortic trauma or altered mechanical stress of the aortic wall tissue associated with bicuspid aortic valves[11–13]. The morbidity and mortality rates seem to be equally high compared to older patients. However, the true prevalence and etiology of AADA in very young patients remain unknown.

Since there is scarce evidence in the literature on very young AADA patients, the aims of this clinical study were to determine the prevalence and potential etiology of AADA in surgically treated patients ≤30 years and to evaluate the respective postoperative outcomes in this selective group of patients with regard to CTD in a large multi-centre study.

MATERIAL AND METHODS

Study Population and Validation

Data collection was performed retrospectively via a case report form (CRF) that had been sent to each participating institution. The participating centres queried their databases for patients ≤30 years of age and the total number of all patients that underwent surgery for AADA. The study cohort (n=139) was divided into two study groups for further comparison with regard to diagnosis of connective tissue disease: CTD group (n=51) and Non-CTD group (n=88).

The collected data comprised the main baseline parameters for AADA at referral as well as intra- and postoperative data with regard to surgical outcomes. Preoperative computed tomography (CT) imaging allowed for determination of dissection extension and potential end-organ malperfusion.

Ethics statement

The local Ethics Committees of the two lead study centres, Universites of Cologne (No. 20-1212) and Berne (KEK-2020-00851). Individual patient consent was waived due to the retrospective design of the study.

Definitions and Statistical Analysis

In-hospital mortality was defined as any death before hospital discharge after surgery. Preoperative lung and renal disease were defined as any clinically relevant impairment of the respective organ systems. Genetic testing was performed according to the respective institutional guidelines using their standardised gene panels. Patients with no or incomplete testing were not included in the CTD group. Previous surgery was defined as any cardiac or aortic operation prior to AADA onset. End-organ malperfusion was defined with regard to the TEM classification as M0 (no malperfusion), M1 (coronary malperfusion), M2 (supraaortic malperfusion) or M3 (spinal, visceral, iliac malperfusion). Clinical malperfusion was defined as evident clinical symptoms of malperfusion of the respective organ-systems correlating with CT imaging. Postoperative respiratory insufficiency was defined as prolonged ventilation (>7days), need for re-intubation or tracheostomy. Renal insufficiency was defined with regard to temporary or permanent need for dialysis. Postoperative stroke or paraplegia were only counted if the neurologic damage occurred after surgery.

Categorical variables were reported using absolute and relative frequencies. Continuous variables were expressed by mean (± standard deviation) or as median with interquartile range (IQR; 25th-75th percentile). Tests between groups were performed using chi-squared tests for categorical variables and *t*-tests for continuous variables. Since this is a study of exploratory character, *p*-values were not adjusted for multiplicity and had to be interpreted descriptively (*p*-values <0.05 were defined as statistically significant). The impact of the available variables on in-hospital, 1- and 5-year mortality were analyzed using a multivariable regression models. The binary logistic regression models were constructed with the available variables and the risk factors with a p-value <0.1 (**Table4**). A two-tailed p <0.05 or less was considered to be statistically significant. Survival estimation was performed by the Kaplan-Meier method. Statistical analyses were performed using SPSS software (version 27.0, IBM, Armonk, NY,USA) for data analysis and visualization.

RESULTS

Sixteen international aortic centres responded to the call of the EACTS Task Force for Connective Tissue Disease and agreed to participate in this clinical study. Between the years 1997 and 2021, the total number of surgical AADA cases in the 16 available databases was 7914 with an overall prevalence of patients ≤30 years of 1.8% (n=139). The mean prevalence of cases ≤30 years was 2.2(±1.7)% for the entire study group (**Figure1**). CTDs could be diagnosed in 51(36.7%) patients. The mean follow-up time was 4.0 (±2.5) years.

Preoperative Demographics and Etiology

The mean age of the entire study cohort was 25.6±3.8 years and comprised mainly males (75.5%) (**Figure 2**). Within the CTD group, Marfan syndrome was the most prevalent CTD (n=44;86.2%), followed by Turner (7.8%) and Loeys-Dietz (5.9%) syndromes. The non-CTD group showed significantly higher prevalences of arterial hypertension (46.6%vs.9.8%; p<0.001) and renal disease (11.4%vs.0%;p=0.013), while a positive family history was significantly more often present in the CTD group (17.7%vs.4.5%;p=0.015);with an overall incidence of 9.4% for the entire study group. Moreover, no significant differences were found between the CTD and non-CTD group (**Table1**).

Interestingly, only 6 (4.3%) out of the 139 study patients were younger than 18 years (mean age 14.5±2.1 years) suffering from CTD and arterial hypertension in 3 (50%) and 1 (17%) cases, respectively.

Dissection-specific data

The proximal thoracic aorta was significantly more often affected by AADA in the CTD group: aortic root (84.3% vs. 56.8%; p<0.001), ascending aorta (98.0% vs. 83%; p=0.005) and aortic arch (84.3% vs. 67.1%; p=0.029). No significant differences with regard to dissection extension could be found further downstream of the aorta (**Supplemental table1**).

The most prevalent entry site was located in the ascending aorta (79.1%;E1), followed by the aortic arch and root in 8.6%(E2) and 7.2%(E0), respectively. End-organ malperfusion of the entire study group(n=139) was diagnosed with the TEM classification in 7.2% (M1), 7.2%(M2) and 10.1 (M3), respectively. Indicative clinical symptoms, with the exception of coronary malperfusion, differed considerably from the TEM classification: coronary(7.9%), cerebral(1.4%), visceral/spinal/iliac(16.6%). There were no significant differences regarding

entry tear locations and the incidence of end-organ malperfusion(TEM and clinical symptoms) between the CTD and non-CTD groups (**Supplemental table1**).

Intraoperative data

Aortic root replacement was significantly more often performed in the CTD group (88.2% vs. 39.8%%; p<0.001), with the Bentall operation as the most preferred technique (68.6% vs. 30.7%; p<0.001). Valve sparing root replacement was also performed more frequently in the CTD than in the non-CTD group but did not reach statistical significance (19.6% vs. 9.1%; p=0.133).

Total arch replacement—regardless of the surgical technique—was significantly more often performed in CTD patients (49.0% vs. 31.8%; p=0.048). The most frequent techniques to address the aortic arch were hemiarch (30.9%), frozen elephant trunk (FET; 25.9%) and classic total arch (no ET/FET; 10.8%) techniques. The CTD patients were treated more often with non-hybrid arch replacements but without statistical significance (17.7% vs. 6.8%; p=0.085). The respective intra- and postoperative variables are depicted in **Table 2.**

Postoperative outcomes

Overall in-hospital mortality was 8.6%(n=12) with no significant difference between the CTD and non-CTD groups (9.8%vs.8.0%;p=0.758). Intraoperative death occurred in 4.4%(n=5) while 3.0%(n=4) died after a prolonged postoperative course on the intensive care unit(ICU). The overall 1- and 5-year mortality rates were 2.2% and 1.4%, respectively. After 10 years, actuarial survival was 80% for both groups with no significant differences between the CTD and non-CTD group (Log-rank/Mantle-Cox:p=0.646) (**Figure2**).

Postoperatively, the non-CTD patients showed higher incidences of respiratory (13.6%vs.5.9%;p=0.255) and renal (13.6%vs.9.8%;p=0.598) insufficiency while neurologic complications were equally distributed. No significant differences were found regarding postoperative complications between the two study groups (**Table3**).

Risk factor analysis

Univariate analysis revealed the following parameters as significant predictors of in-hospital mortality: clinical malperfusion(p=0.028), dissection extension beyond the iliac bifurcation(p=0.015), visceral(p<0.001), lower extremity malperfusion(p=0.031) as well as a high(≥11%) GERAADA score(p<0.001). The predictors for 1-year mortality comprised TEM classification M1(p=0.007), re-exploration for bleeding(p=0.023), postoperative renal insufficiency(p=0.040) and temporary need for dialysis(p=0.017). No significant predictors were identified for 5-year mortality by univariate analysis (**Table 4**).

The single independent risk factor for in-hospital mortality identified by multivariable analysis was the presence of an entry tear in the descending aorta (TEM:E3) for the entire study cohort (OR17.411;95%-CI:1.547-195.937;p=0.021). In contrast, the absence of any end-organ malperfusion (TEM classification M0) was independently protective for in-hospital mortality (OR0.121;95%-CI:0.016-0.895,p=0.039). In addition, previous aortic surgery was identified as an independent risk factor for 5-year mortality (OR44.667;95%-CI:2.227-895.969;p=0.013). No independent risk factors for 1-year mortality were identified by multivariable analysis (**Table 4**).

DISCUSSION

Acute aortic dissection type A (AADA) usually occurs in the 6th or 7th decade of life and is rarely seen in patients under 30 years of age[12]. Adolescents and young adults presenting with AADA are a challenge for the surgeon on several levels. The optimal surgical strategy not only has to ensure the immediate survival of the patient but also has to take a life expectancy of several decades into account[16]. Due to the authors knowledge this is the first attempt to focus on very young patients ≤ 30 years that often are thought to be healthy until the immediate and painful onset of AADA—with a prevalence of 1.8% in a large multi-centre cohort of almost 8000 surgical cases.

Interestingly, the vast majority of the study cohort were males (75.5%) with no significant difference between patients with or without CTD. The prevalence of ascending aortic aneurysm and bicuspid aortic valve (BAV) is known to be higher in males, while the onset of aortic dissection may occur earlier and more extensively in females—potentially resulting in worse outcomes compared to male patients[17]. In 2010, Détaint et al. showed an increased risk for aortic dilation and aortic events in young (≤30 years) Marfan males[18]. Most recently, Nucera et al. also reported an increased overall incidence of aortic events in males of up to 71% in a large series of 183 Marfan patients over a period of >25 years, including acute type A and B aortic dissections in 14.1% and 12.6%, respectively[19]. In our study cohort, the overall distribution of CTD and BAV did not significantly differ between male and female patients suffering from AADA. Obviously, Turner syndrome was exclusively present among female patients (11.8%;p=0.003) but no other significant gender specific differences, including age of dissection onset and in-hospital mortality, were identified (**Supplemental table 2**).

Bicuspid aortic valve (BAV) as the most common congenital heart condition has a reported incidence of 0.5-2.0% in the general population as well as in Marfan syndrome (1.8%) [20]. Other authors reported a fourfold or even eightfold increased incidence of BAV in Marfan and Loeys-Dietz syndrome, respectively[21]. In our study cohort, BAV patients had no positive family history of aortic disease but almost one-fifth(18.8%) were also diagnosed with CTD, which highlights the importance of differential genetic diagnosis by sequencing technologies in BAV patients(**Supplemental table 3**).

Most interestingly, there was a positive family history in almost every 10th patient (9.8%) of the 139 included cases. In the CTD group—representing more than one-third (36.7%) of the entire study cohort—the incidence of a positive family history of aortic disease was significantly increased (17.7%), potentially allowing for preoperative diagnosis and timely surgery in almost every 5th patient suffering from CTD. The most frequent CTD identified was Marfan syndrome, followed by Turner and Loeys-Dietz syndromes. Notably, no patient was diagnosed with any

form of Ehlers-Danlos syndrome. The current guidelines already recommend screening of all 1st degree relatives from patients presenting with thoracic aortic disease. These findings stress the need for echocardiographic screening of relatives and genetic testing of patients with thoracic aortic disease regardless of age which may help to avoid AADA in the first place[22].

Preoperatively, there was a significant difference between CTD and non-CTD patients regarding the incidence of arterial hypertension. While the overall prevalence of arterial hypertension was approximately one-third (33.1%) in the study cohort, almost half of the non-CTD group was affected(46.6%). However, without CTD as the most obvious trigger for AADA the authors of this study would have expected an even higher incidence or arterial hypertension in the non-CTD group.

In the year 2000, the worldwide prevalence of arterial hypertension in young adults (20 to 29 years) was respectively estimated respectively to be 7.4% and 12.7% for females and males, with a predicted increase of the prevalence of hypertension of 60% by the year 2025[23]. In the United States the estimated prevalence of patients aged 18-39 years between 2011 and 2012 was 7.3%. In addition, prevalence of an underlying cause—by means of secondary hypertension—in affected young adults is reported to be only 5.3%, comprising hypothyroidism (1.9%), renovascular disease (1.7%), renal insufficiency (1.5%), primary hyperaldosteronism (1.2%), Cushing syndrome (0.5%), and pheochromocytoma (<0.3%)[24]. Most likely, the affected study patients suffered from undiagnosed arterial hypertension—with increased risk for short- and mid-term cardiovascular adverse events—for a long time, potentially allowing early diagnosis and subsequent medical treatment. However, the awareness of an illness and a slower diagnosis rate may also play an important role here, since regular primary care physician visits are usually lacking and potential symptoms, e.g. headache, dizziness, etc., might be misinterpreted or dismissed by younger individuals[24,25].

The extension of AADA plays an important role in the preoperative planning of the surgical strategy (e.g. choice of cannulation site, cerebral perfusion, hypothermic conditions, etc.) and intraoperatively used operative techniques (e.g. hybrid vs. non-hybrid prothesis)[26,27]. The CTD group showed significantly higher rates of proximal aortic involvement, including the aortic root and arch, while the downstream aorta seemed equally affected. Consequently, surgery of the root, either as a valve-sparing or Bentall operation, and arch were required significantly more often in CTD patients. Some authors strongly suggest that the aortic root and arch should be treated more aggressively in young AADA patients, and especially when CTD is present, to avoid reoperations due to aortic valve regurgitation, aneurysms and re-dissections on the long-term[28–30].

In comparison with the current literature, in-hospital mortality was exceptionally low(8.6%) for the entire study group and did not significantly differ between the both groups

(9.8%vs.8.0%; p=0.758)—despite a more radical surgical approach on the proximal aorta in the CTD group. The only independent risk factor identified for in-hospital mortality was an entry tear in the descending aorta(n=6)—which may either be due to retrograde type A aortic dissection or just falsely identified re-entries. However, out of the six affected patients classified as E3 by TEM, three underwent total arch surgery but only two received a FET procedure, while the two patients who died in hospital had been treated with a hemiarch and ascending replacement. The FET procedure is the gold standard in elective arch surgery to treat aneurysms involving the distal arch and proximal descending aorta[31]. In AADA patients the FET technique not only facilitates positive aortic remodeling in the postoperative course but also may cover (re-)entry tears in the descending aorta[32]. However, some surgeons are reluctant to use hybrid or endovascular stent grafts in patients with CTD[8]—which might explain the slight trend toward more classic total arch replacements in the CTD group.

Malperfusion of end-organ systems has been widely recognized to be directly associated with adverse outcomes in AADA patients[1,2,9]. This is in line with the identified predictors of in-hospital mortality in this study, such as a high GERAADA score (≥11%), extensive dissection beyond the iliac artery bifurcation, presence of clinical symptoms and visceral or lower extremity malperfusion. Naturally, the absence of end-organ malperfusion (TEM: M0) is expected to result in significantly better outcomes and was shown to be independently protective from in-hospital mortality in this study.

The respective short- and mid-term outcomes, with regard to mortality rates at 1 and 5 years, were excellent and also not significantly different between CTD and non-CTD patients. In addition, actuarial survival at 10 years was still 80% for the entire cohort. Interestingly, no independent risk factors for 1-year mortality could be identified by multivariable analysis despite the several significant predictors from the univariate analysis, including coronary malperfusion (M1), re-exploration for bleeding and postoperative renal insufficiency with need for temporary dialysis. The overall incidence of postoperative complications did also not significantly differ between the two study groups. However, non-CTD patients showed higher, but not significantly increased, incidences of renal (13.6% vs. 5.9%) and respiratory insufficiency (13.6% vs. 9.8%).

The only identified risk factor for 5-year mortality was previous aortic surgery. Although the number of affected patients was low (n=4), previous aortic surgery was associated with a 44-fold increased mortality risk at five years and underlines the importance of ‘complete’ proximal aortic replacement at the primary operation. Aortic re-do surgery usually becomes more difficult and often requires removal of old prosthetic or endovascular stent material, which may even be more difficult in the hemodynamically unstable patient or in cases of excessive bleeding due to AADA. As a consequence, surgery might be performed less extensively than

required, ultimately leaving the individual AADA patient at an increased risk for long-term complications and aortic related death.

With regard to the postoperative early and mid-term results of this study, the authors advocate for more extensive aortic root and arch replacement in patients ≤30 years (with or without CTD), specifically with the use of the FET procedure if an entry or re-entry tear has been diagnosed in the descending aorta. In addition, a thorough patient history and screening of 1st degree relatives should be performed in all patients with thoracic aortic disease and/or BAV to potentially identify CTDs and to prevent future AADA in collateral relatives.

Limitations of the study

The authors acknowledge that the retrospective design and descriptive character of the presented study are major weaknesses and that the presented results have to be interpreted with care. Moreover, genetic testing was not performed in all study patients as a routine diagnostic procedure, leaving patients with no or incomplete testing in the Non-CTD group. Information on re-operations during follow-up was not available from all participating centres and therefore left out. However, the presented study is currently the largest cohort of AADA patients ≤30years and therefore, adds important insights to the cardiovascular community by increasing the awareness and potentially improving the surgical treatment of AADA in the adolescents and young adults.

CONCLUSION

The prevalence of AADA in surgically treated patients ≤30 years is less than 2% with CTD and arterial hypertension as two most frequent triggers. Surgery may be performed with good results and excellent mid- to long-term outcomes. However, previous screening in patients with phenotypic signs of CTD, BAV or a positive family history may have prevented AADA in more than one-third of study patients.

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TABLES:

Table1: Patient baseline characteristics

Parameters,n(%)	All patients (n=139)	CTD group (n=51)	No-CTD group (n=88)	*p*-value
Age(mean±SD)	25.6(±3.8)	25.2(±4.3)	25.8(±3.5)	0.372
Male gender	105(75.5%)	38(74.8%)	67(76.1%)	0.840
CAD	1(0.7%)	1(2.0%)		0.366
Hypertension	46(33.1%)	5(9.8%)	41(46.6%)	**<0.001***
Lung disease	2(1.4%)		2(2.3%)	0.532
Renal disease	10(7.2%)		10(11.4%)	**0.013***
Pos. family history	13(9.4%)	9(17.7%)	4(4.5%)	**0.015***
Aortic aneurysm	26(18.7%)	12(23.5%)	14(15.9%)	0.270
Bicuspid aortic valve	16(11.5%)	3(5.8%)	13(14.8%)	0.167
CTD	51(36.7%)	51(100%)		**<0.001***
Marfan	44(31.7%)	44(86.2%)		
Loeys-Dietz	3(2.2%)	3(5.9%)		
Turner	4(2.9%)	4(7.8%)		
Trauma	1(0.7%)		1(1.1%)	0.366
Preoperative Tamponade	5(3.6%)	3(5.9%)	2(2.3%)	0.356
Preoperative Neurology	7(5.0%)	1(2.0%)	6(6.8%)	0.422
Coma	1(0.7%)		1(1.1%)	0.366
Paraplegia	1(0.7%)		1(1.1%)	0.366
Minor peripheral	5(3.6%)	1(2.0%)	4(4.6%)	0.652
Previous cardiac surgery	5(3.6%)	-	5(5.7%)	0.158
AV replacement	2(1.4%)	-	2(2.3%)	0.532
MV repair	1(0.7%)	-	1(1.1%)	1.000
Congential heart surgery	2(1.4%)	-	2(2.3%)	0.532
Previous aortic surgery	4(2.9%)	1(2.0%)	3(3.4%)	1.000
Valve sparing aortic root	1(0.7%)	-	1(1.1%)	1.000
Descending replacement	1(0.7%)	-	1(1.1%)	1.000
Abdominal replacement	1(0.7%)	-	1(1.1%)	1.000
TEVAR	1(0.7%)	1(2.0%)	-	0.366
GERAADA Score (±SD)	7.8(±3.4)%	7.8(±3.3)%	7.8(±3.4)%	1.000

CTD=connective tissue disease;SD=standard deviation;CAD=coronary artery disease;TEM=type,entry site,malperfusion;=statistically significant*

Table2: Intraoperative data

Parameters,n(%)	All patients (n=139)	CTD group (n=51)	No-CTD group (n=88)	*p*-value
Aortic replacement				
Root	80(57.6%)	45(88.2%)	35(39.8%)	**<0.001***
Valve sparing	18(13.0%)	10(19.6%)	8(9.1%)	0.113
David	15(10.8%)	9(17.7%)	6(6.8%)	0.085
Yacoub	1(0.7%)	1(2.0%)		0.366
Other	2(1.4%)		2(2.3%)	0.298
Bentall	62(44.6%)	35(68.6%)	27(30.7%)	**<0.001***
Ascending	130(93.5%)	48(94.1%)	82(93.2%)	1.000
Hemiarch	43(30.9%)	14(27.5%)	29(33.0%)	0.570
Total arch	53(38.1%)	25(49.0%)	28(31.8%)	**0.048***
Total(noET/FET)	15(10.8%)	9(17.7%)	6(6.8%)	0.085
Elephant trunk	2(1.4%)	1(2.0%)	1(1.2%)	1.000
FET	36(25.9%)	15(29.4%)	21(23.9%)	0.547
Descending	1(0.7%)		1(1.2%)	1.000
Concomitant procedures	8(5.8%)	1(2.0%)	7(8.0%)	0.257
CABG	6(4.3%)	1(2.0%)	5(5.7%)	0.414
ASD closure	1(0.7%)	-	1(1.2%)	1.000
Mitral valve repair	1(0.7%)	-	1(1.2%)	1.000

ET= Elephant trunk;FET=Frozen ET;AVR=aortic valve replacement;*=*statistically significant*

Table3: Postoperative outcomes

Parameters,n(%)	All patients (n=139)	CTD group (n=51)	No-CTD group (n=88)	*p*-value
In-hospital mortality	12(8.6%)	5(9.8%)	7(8.0%)	0.758
Intraoperative	5(4.4%)	2(3.9%)	3(3.4%)	1.000
Postoperative	7(3.0%)	3(5.9%)	4(4.6%)	0.707
Follow-up mortality	9(6.5%)	4(7.8%)	5(5.7%)	0.724
1-year mortality	3(2.2%)		3(3.4%)	0.553
5-year mortality	2(1.4%)	1(2.0%)	1(1.4%)	1.000
Cumulative mortality	21(15.1%)	9(17.6%)	12(13.6%)	0.624
Re-exploration	13(9.4%)	5(9.8%)	8(9.1%)	1.000
Respiratory insufficiency	15(10.8%)	3(5.9%)	12(13.6%)	0.255
Ventilation(>7d)	5(3.6%)	2(3.9%)	3(3.4%)	1.000
Reintubation	3(2.2%)	1(2.0%)	2(2.3%)	1.000
Tracheostomy	7(5.0%)	1(2.0%)	6(6.8%)	0.422
Renal insufficiency	17(12.2%)	5(9.8%)	12(13.6%)	0.598
Temporary dialysis	11(7.9%)	3(5.9%)	8(9.1%)	0.746
Permanent dialysis	4(2.9%)	1(2.0%)	3(3.4%)	1.000
Stroke	4(2.9%)	2(3.9%)	2(2.3%)	0.624
Paraplegia	4(2.9%)	2(3.9%)	2(2.3%)	0.624

CTD=connective tissue disease;d=days;=statistically significant*

Table4: Predictors and risk factors for in-hospital 1-year and 5-year mortality by univariate and multivariable regression for the entire study cohort(n=139)

Parameters				*p*-value
Univariate analysis				
In-hospital mortality				
TEM classification E3				0.086
TEM classification M0				0.085
Clinical malperfusion				**0.028***
Dissection extension iliac arteries				**0.015***
Preoperative coma				0.086
Visceral malperfusion				**<0.001***
Lower extremity malperfusion				**0.031***
High GERAADA score				**<0.001***
1-year mortality				
TEM classification M1				**0.007***
Re-exploration for bleeding				**0.023***
Postoperative renal insufficiency				**0.040***
Temporary need for dialysis				**0.017***
5-year mortality				
Previous aortic surgery				0.057
		95%-Confidence interval		
	Odds ratio	low	high	*p*-value
Multivariable analysis				
30-day mortality				
TEM classification E3	17.411	1.547	195.937	**0.021***
TEM classification M0	0.121	0.016	0.895	**0.039***
5-year mortality				
Previous aortic surgery	44.667	2.227	895.969	**0.013***

*TEM=type,entry site,malperfusion.**=statistically significant*

FIGURE LEGEND:

Central image: Prevalence of acute aortic dissection in patients ≤ 30 in all study centres

Figure1: Respective case numbers and distribution with regard to age (≤ 30vs.≥31years) from all study centres.

Figure2: Age distribution of the study cohort (n=139).Red dot equals mean age (25.6years)**.**

Figure3: Survival estimation by Kaplan-Meier method for the entire study cohort (A;n=139) and the two study groups (B):CTD(blue;n=55) vs. non-CTD(green;n=88).

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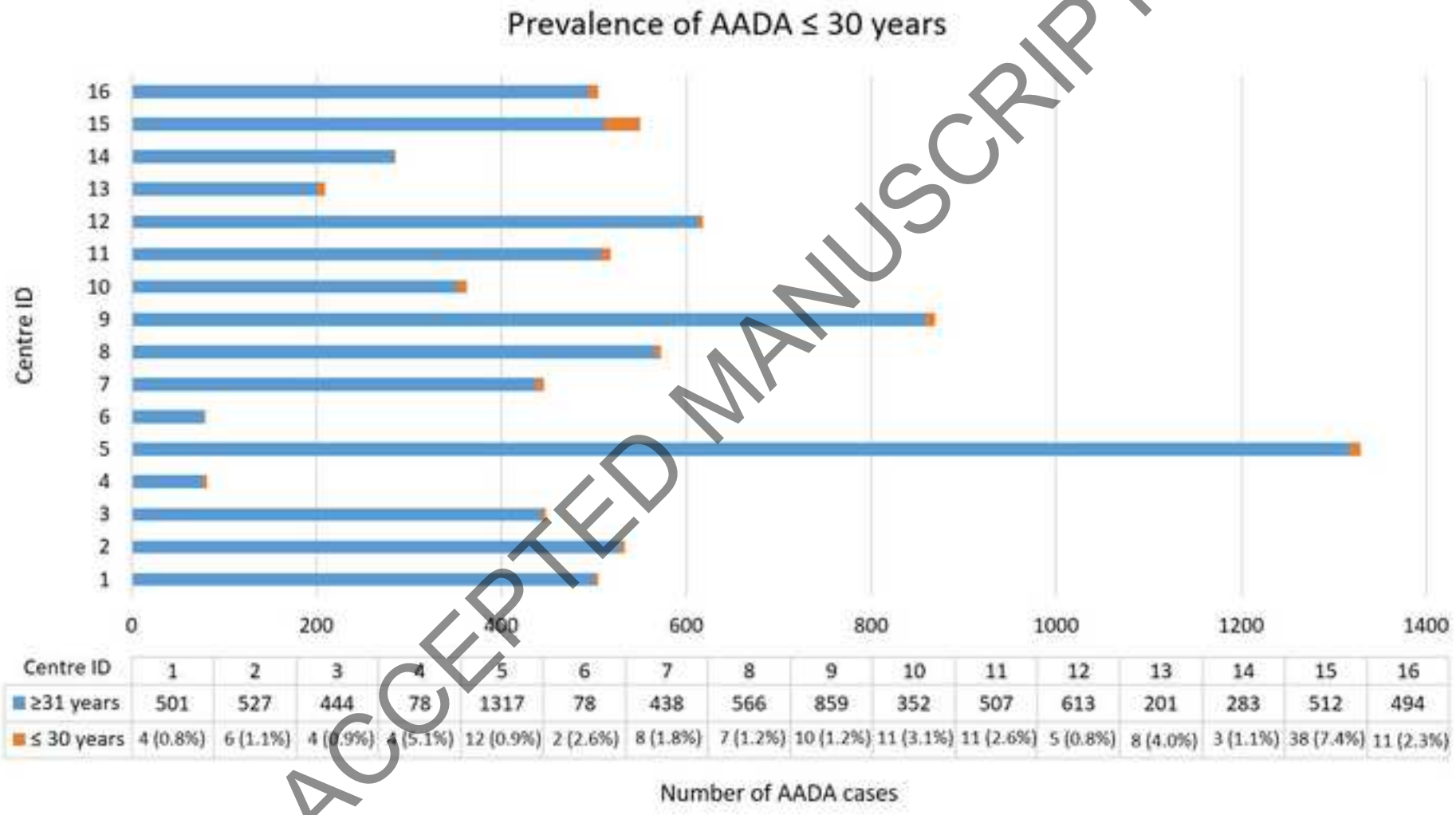
Figure 1



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≤ 30 years	4 (0.8%)	6 (1.1%)	4 (0.9%)	4 (5.1%)	12 (0.9%)	2 (2.6%)	8 (1.8%)	7 (1.2%)	10 (1.2%)	11 (3.1%)	11 (2.6%)	5 (0.8%)	8 (4.0%)	3 (1.1%)	38 (7.4%)	11 (2.3%)

Figure 2

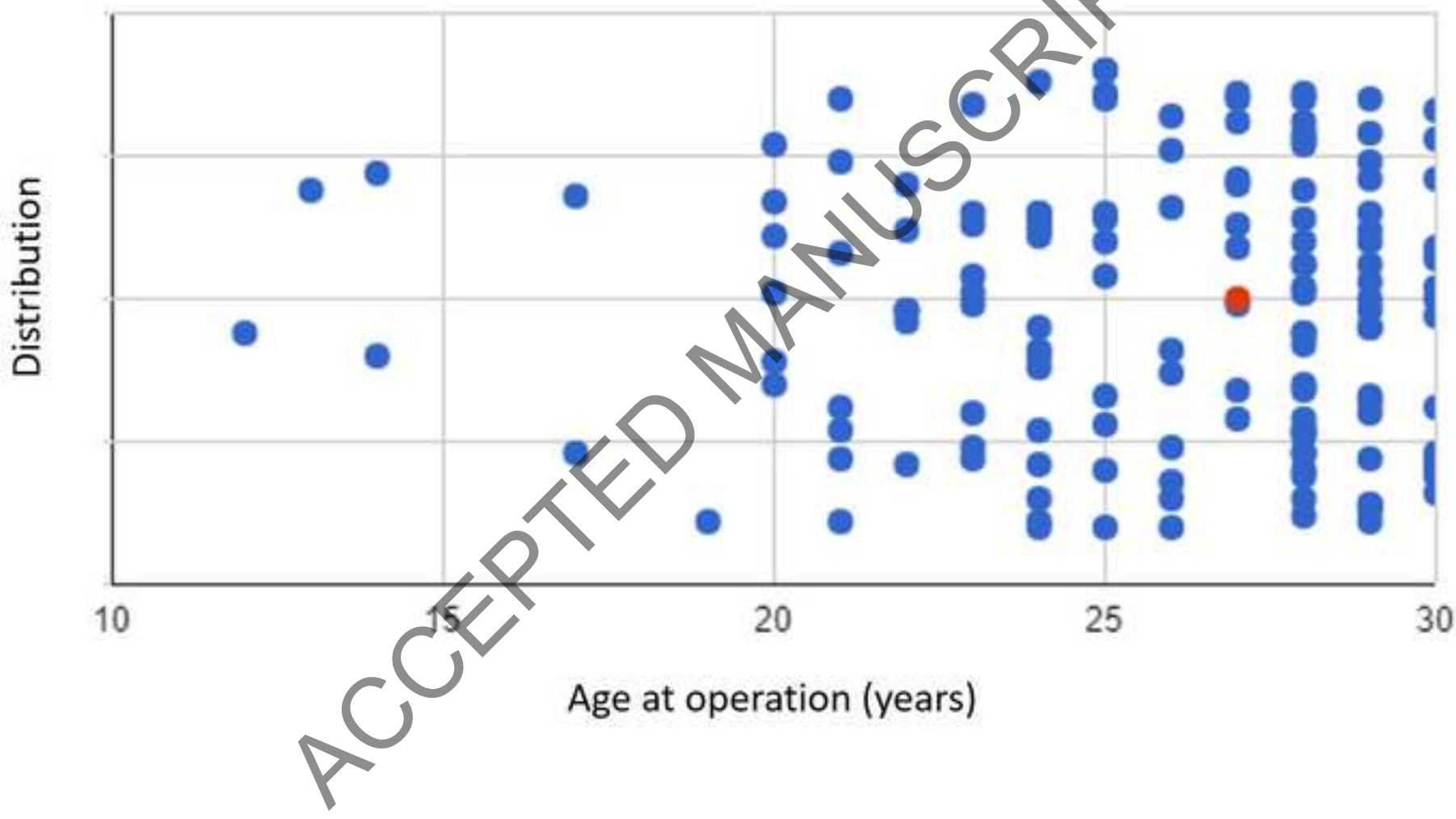
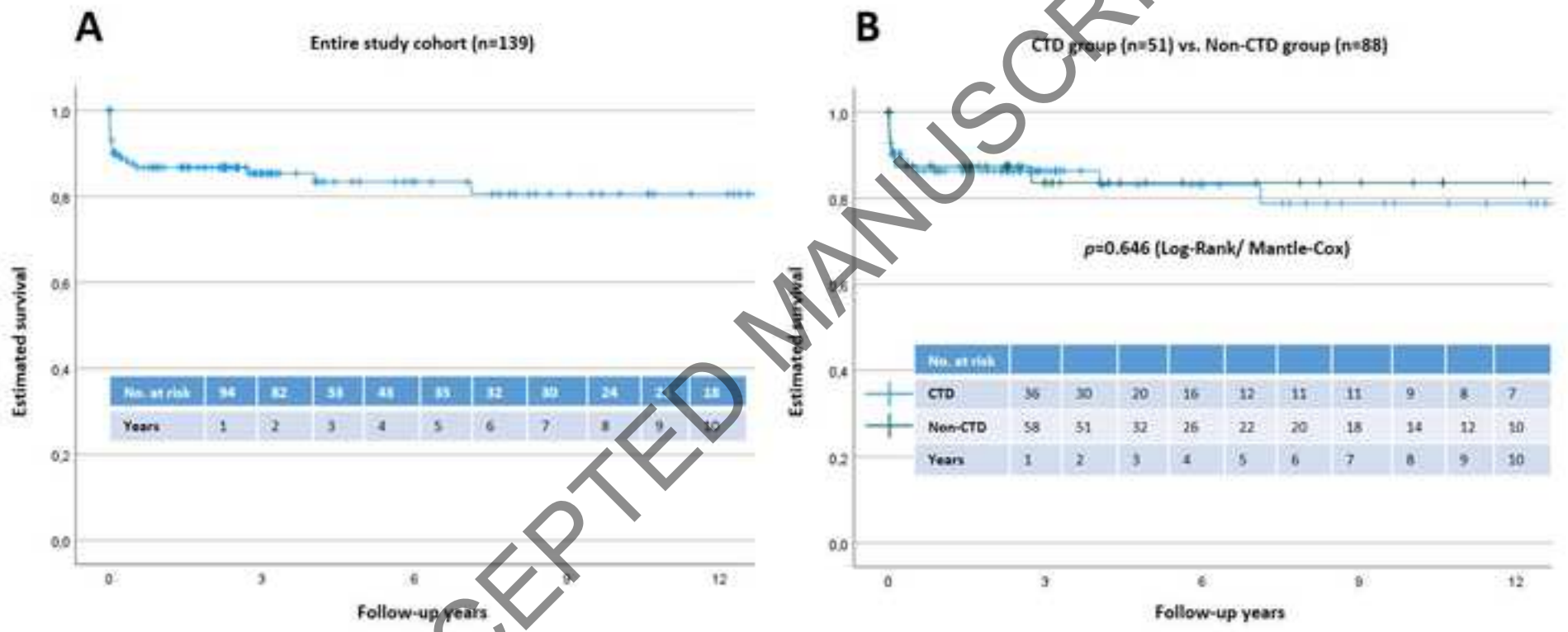
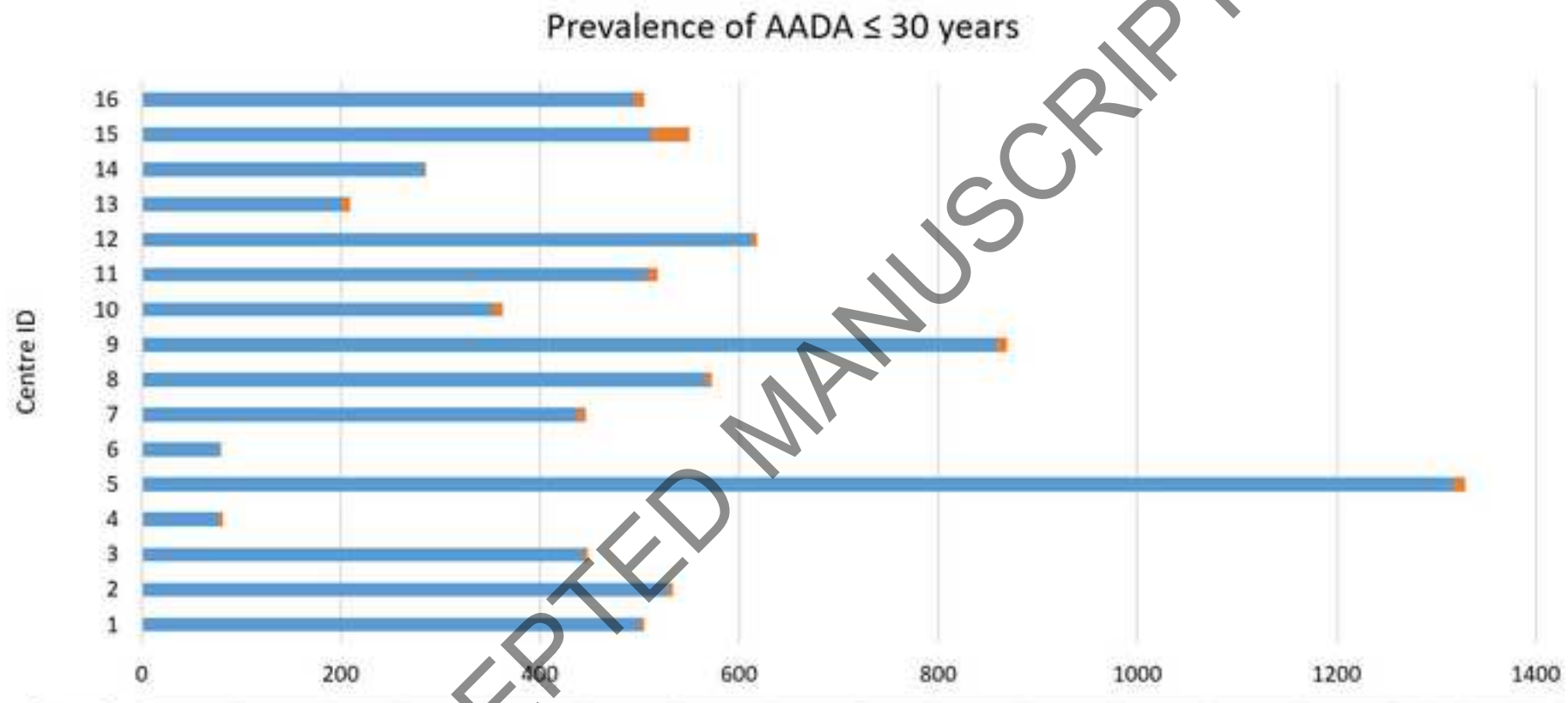


Figure 3



Central image



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