Distal Stent Graft Induced New Entry: Risk Factors in Acute and Chronic Type B Aortic Dissections

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WHAT THIS PAPER ADDS

To reduce the risk of distal stent graft induced new entry (dSINE), the use of tapered stent grafts should be considered in cases with expected high distal oversizing, especially in acute aortic dissections. If dSINE development occurs, patients require special attention in terms of follow up regarding the need for potential re-intervention. Reasons for re-intervention are mostly impending rupture and dSINE growth. However, dSINE has a good prognosis after interventional treatment if discovered early enough. Long term follow up after re-interventions shows mostly satisfying results, including that additional re-intervention is not necessary even after years.

Objectives: Distal stent graft induced new entry (dSINE) is a rare complication associated with acute and chronic dissections after thoracic endovascular aortic repair (TEVAR) and is linked to a high re-intervention rate. The potential predicting risk factors for dSINE and long term outcome of patients after re-intervention were analysed.

Methods: This single centre, retrospective study included patients undergoing TEVAR. Multivariable analysis was used to test important interventional parameters such as distal oversizing (dOS), taper ratio (TR), angle between distal stent graft and aorta, acute dissection and stent graft length. Re-intervention characteristics were analysed and further long term follow up after re-intervention were evaluated.

Results: One hundred and eighty-five patients were analysed with acute (n = 77) and chronic (n = 108) dissections after TEVAR with an average follow up of 68.9 ± 32.5 months. During follow up, 12 (6.5%) patients developed dSINE after a median of 22.2 ± 20.7 months. Acute dissection was identified as a major predicting factor for dSINE development (15.8 fold increased odds), followed by increased dOS and TR. The re-intervention rate was higher in the dSINE group (83% *vs.* 20%, p = .001), but results indicated that no further re-intervention was needed and no new endoleak development occurred up to a mean follow up of 60.7 ± 54.8 months. No dSINE was seen in association with tapered stent grafts.

Conclusions: Acute aortic dissection was found to be the major predicting factor for dSINE development, followed by increased dOS and TR. The use of tapered stent grafts might be beneficial for patients with high expected dOS and TR. In the rare case of dSINE occurrence, even when re-intervention is required, the long term prognosis is good.

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INTRODUCTION

Thoracic endovascular aortic repair (TEVAR) is an emerging option for the treatment of thoracic aortic diseases, with the advantages of reduced early mortality and morbidity compared with open surgery.[1,2] Interventional stent graft deployment must be performed meticulously to reduce peri-procedural complications, but the challenge begins in choosing the appropriate stent graft size. Stent graft migration and dissection progression are serious complications of undersized stent grafts, whereas excessive oversizing can damage the fragile aortic wall and cause retrograde dissection.[3–5] A widely accepted treatment method is oversizing of the stent graft by 10% at the proximal landing zone (PLZ) to achieve reliable coverage of the proximal entry tear[6,7] in aortic dissections. The main

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goal is to reduce further perfusion of the false lumen, and to induce thrombosis. Focusing on the PLZ may lead to neglect of the distal end, and use of non-tapered stent grafts does not reflect the high taper ratio of the descending aorta. Distal stent graft induced new entry (dSINE) is a rare complication that can occur at the distal end of the stent graft, caused by distal oversizing (dOS) and the resulting sheer strain between the stiff stent graft and the fragile aortic wall. It is defined as a new tear caused by the stent graft itself, excluding the associated factors of disease progression and iatrogenic injury during the endovascular procedure.[8]

The aim of the current study was to identify predictors/risk factors of dSINE through a retrospective analysis of computed tomography (CT) data before and after TEVAR, and at follow up. Additionally, the long term outcome of dSINE re-intervention was analysed. No studies regarding the long term results of dSINE are currently available, because of the rarity of the condition.

MATERIALS AND METHODS

Study design and patient characteristics

In this single centre, retrospective study, patients with type B aortic dissection who underwent TEVAR between February 2000 and August 2016 were evaluated. Written informed consent to vascular access and subsequent endovascular procedure was obtained from every patient. Clinical follow ups were performed at the study institution. Aortic dissection was considered acute when it occurred within the first 14 days of symptom onset, whereas beyond two weeks it was considered to be chronic. Indications for treatment were in accordance with the current guidelines.[5,9]

The study and its protocols were approved by the local ethics committee. Patient records were de-identified and analysed anonymously; therefore, the need for consent for retrospective analysis of patient data was waived.

Computed tomography studies

Contrast enhanced, electrocardiogram triggered, high resolution ($\leq$1.5 mm slice thickness) CT angiography (CTA) was performed with the newest scanner generation, varying from 16 slice to 384 slice dual source systems (SOMATOM Sensation 16 in 2000 up to SOMATOM Force since 2014, Siemens Healthineers, Forchheim, Germany). CTA scans were analysed using Osiris software, version 5.5.2, 64 bit (Pixmeo Sàrl, Bernex, Switzerland). Continuous scans covered the entire aorta, including the proximal supra-aortic vessels down to the groin. Iodinated contrast (100—140 mL) was injected continuously into the right antecubital vein via an 18 G catheter at an infusion rate of 4.0 mL/s. To ensure maximum concentration of contrast agent in the aorta, a circular region of interest (ROI) was defined in the ascending aorta. As soon as the signal intensity in the ROI reached a threshold of 120 Hounsfield units (HU), the patient was instructed to maintain an inspiration breath hold and data acquisition commenced. A second venous phase scan covering the same area was performed after a delay of 50 s.

Primary endovascular procedure

The primary endovascular procedure was performed in the Hybrid operation room by a team of interventional cardiologists, cardiothoracic surgeons, and anaesthetists; under general anaesthesia with mechanical ventilation, as previously described.[10] The following stent grafts were used for both the primary endovascular procedure and re-intervention where necessary: Talent, Valiant, and Valiant-Captivia (Medtronic, Minneapolis, MN); Relay and Relay Plus (Bolton Medical, Barcelona, Spain); and GORE TAG (W.L. Gore & Ass., Flagstaff, AZ, USA). The stent graft size was chosen to include 10% oversizing (Medtronic, Bolton Medical), or was obtained from the range of the manufacturer's guidelines (Gore). Availability meant that tapered stent grafts were first used at the study institution in early 2010. The decision on stent graft strategy, including use of tapered *vs.* non-tapered stent grafts was made by the aortic team, which included an interventional cardiologist with proven experience in TEVAR, an experienced cardiothoracic surgeon, and an anaesthetist.

Follow up

Strict surveillance protocols are required after surgical or interventional thoracic aortic repair to manage relevant comorbidities such as arterial hypertension and detect possible complications at an early stage.[5] As no definitive guidelines exist, the following were used: the standard protocol regarding follow up examinations after TEVAR included an initial CTA before discharge for result documentation. Further follow up examinations always included CTA and were scheduled via the cardiology outpatient clinic at one, three, six, and 12 months after TEVAR, and on a yearly basis thereafter. Additional or earlier follow up visits were scheduled at the discretion of the responsible cardiologist depending on disease progression. Every CTA included assessment of the location and integrity of the implanted stent graft, the aortic diameter with perfusion of the true/false lumen, and the presence of endoleaks. Two independent observers performed CT scan analyses in a blinded manner.

Definition and indication for treatment of distal stent graft induced new entry

The development of dSINE was defined as the new appearance of an intimomedial injury resulting in a new patent false lumen in close relationship with the distal stent graft as a consequence of mechanical friction and sheer stress between the distal stent graft and the descending aorta. A representative example of dSINE before and after treatment is shown in Fig. 1A—C.

Two main treatment modalities were applicable after dSINE detection: 1) medical treatment was the preferred option, focusing on blood pressure normalisation to keep the systolic blood pressure $<$140 mmHg; and 2) TEVAR as a re-intervention strategy. Indications for re-intervention were further growth of the false lumen despite intensified medical treatment, rapid growth that did not allow medical treatment alone, or contained rupture or symptoms because of malperfusion. After detection of dSINE, intensified follow up that included CTA was scheduled to take place after three months. In cases where dSINE extended to more than 30% of the aortic diameter or where rapid progression with 50% growth was seen, the aortic team for each case discussed the feasibility and probability of successful re-intervention. Orthogonal sectional planes were used to minimise the risk of overestimation. The choice of stent grafts used for re-intervention was at the discretion of the treating physician.

Data analysis

CTA images were analysed for evidence of new distal erosion of the intimomedial membrane or progression of aneurysmal expansion. Definitions of the calculated or assessed parameters are as follows (Fig. 1D):

- Proximal oversizing: Oversizing ratio of the PLZ = (stent graft diameter − estimated PLZ diameter before implantation)/estimated PLZ diameter before implantation
- Distal oversizing: Oversizing ratio of the distal landing zone (DLZ) = (stent graft diameter − estimated DLZ diameter before implantation)/estimated DLZ diameter before implantation
- Taper ratio = (PLZ diameter − DLZ diameter)/PLZ diameter
- Angle between the distal end of the stent graft end and the continuation of the aorta: Multiplanar reconstruction images elaborated from axial CT images were used to measure the angle between distal stent graft and the continuation of the aorta, cut longitudinally through the middle of the stent graft for standardised measurement.

The calculations above refer to measurements of the mean diameter of the true lumen. Measurements were performed by a single observer who was not aware of the current study. In some cases, the maximum diameter was used and specified separately.

Statistical analysis

Continuous variables are presented as means ± standard deviation, while categorical variables are presented as frequencies and percentages. The differences in characteristics of patients classified as dSINE and non-dSINE were compared using a two sided *t* test for continuous variables and Fischer's Exact test for binary variables. The differences between continuous variables were compared using the Mann—Whitney *U* test. Binomial logistic regression was

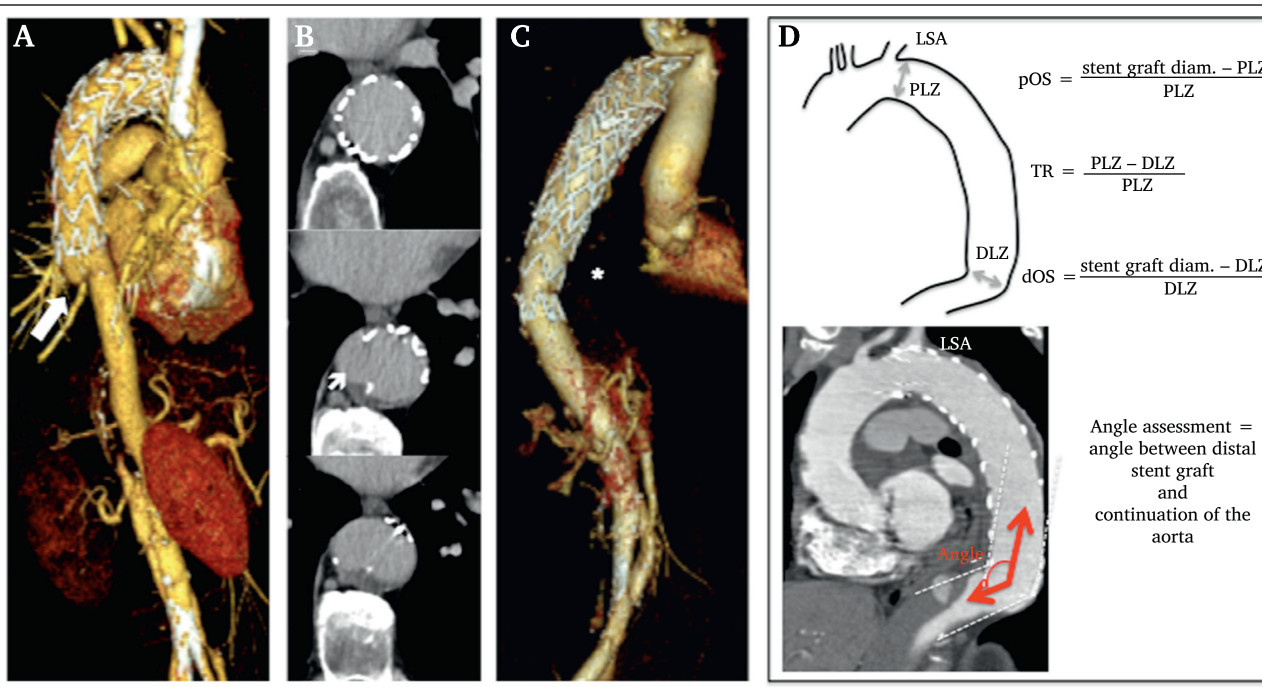

Figure 1. Representative examples of distal stent graft induced new entry. Images show distal stent graft induced new entry dSINE in a 64 year old male with chronic aortic dissection at the distal end of the stent graft (arrow), detected 18.4 months after primary endovascular intervention as (A) a CT 3D reconstruction of dSINE before treatment and (B) 2D CT study after treatment. (C) Post-re-intervention result 42.3 months after intervention with stent graft expansion (*) and no recurrence of dSINE. (D) Upper part: schematic illustration of the assessment and calculation of pOS, TR, and dOS. Lower part: the descending aorta after stent graft implantation. Dashed lines indicate the courses of the descending aorta and distal stent graft, and the resulting angle. CT = computed tomography; diam. = diameter; DLZ = distal landing zone; dOS = distal oversizing; dSINE = distal stent graft induced new entry; LSA = left subclavian artery; PLZ = proximal landing zone; pOS = proximal oversizing; TR = taper ratio.

performed to ascertain the effects of the taper ratio, the angle between the distal stent graft and the descending aorta, dOS, acute aortic dissection, and stent graft length on the likelihood that patients will develop dSINE. The linearity of continuous variables was assessed with respect to the logit of the dependent variable via the Box-Tidwell procedure.[11] Based on this assessment it was found that all continuous independent variables were linearly related to the logit of the dependent variable. Kaplan—Meier analysis was used to estimate freedom from re-intervention after dSINE development. Values of $p < .05$ were considered statistically significant. All data and statistical analyses were performed using SPSS 24 (SPSS Inc, Chicago, IL, USA) for Mac and Microsoft Excel 2011 for Mac.

RESULTS

Study population and thoracic endovascular aortic repair procedure

A total of 185 patients with type B aortic dissection underwent TEVAR between February 2000 and August 2016. Relevant patient demographics are shown in Table 1. Indications for TEVAR in chronic dissections were mainly malperfusion (visceral, renal, or peripheral; $n = 36$, 33%), followed by reaching the critical diameter of 5.5 cm ($n = 33$, 31%) and fast progression of false lumen expansion ($n = 30$, 28%). Further indications were refractory hypertension ($n = 5$, 5%) and refractory pain ($n = 4$, 4%). For primary intervention, one stent graft was used in 143 patients (77%), two in 36 patients (19%), and three in six patients (3%). The predominant strategy included the use of non-tapered stent grafts (159 patients). A tapered stent graft was used during the primary endovascular procedure in 26 patients. Of these, 22 patients had a 4 mm difference between the proximal and distal graft diameters, two had a 2 mm difference, and two a of 6 mm difference. The mean covered stent graft length was 162.4 ± 40.5 mm (range 20—270 mm) with a proximal diameter of 34.1 ± 4.6 mm (range 24—46 mm). Pre-procedural distal mean aortic diameters were comparable between groups (dSINE: 29.6 ± 10.4 mm, non-dSINE: 27.0 ± 14.7 mm; $p = .552$).

Follow up after initial thoracic endovascular aortic repair procedure

Follow up was continued until July 2017, with a mean follow up of 68.9 ± 32.5 months (range 4—167 months). After one year, patient scans for 85% of the original study population were available (158 patients completed scans at follow up, 25 had died); after five years, scans were available for 72% of the patients (135 patients completed scans for follow up, 42 had died), and after six years, scans for 69% of the patients were available (129 patients completed scans for follow up, 44 had died).

The 30 day mortality rate was 6.2% (13 patients), four of whom died for non-aortic reasons. The five year mortality rate was 23%. None of the patients with dSINE died within the follow up period. During follow up, type I endoleak was detected in 19 patients (10.2%) and migration of the implanted stent graft in three patients (1.6%).

Detection of distal stent graft induced new entry and primary stent graft strategy

A total of 12 of the 185 patients developed dSINE (6.5%), 10 of whom underwent re-intervention. The mean time from the primary endovascular procedure to initial diagnosis of dSINE was 22.2 ± 20.7 months (range 4—72.5 months), and from the primary endovascular procedure to re-intervention was 25.6 ± 23.1 months (range 4.2—74.5 months). The mean total follow up time for dSINE patients was 60.7 ± 54.8 months (range 7.2—167.6 months), representing the time from the primary endovascular procedure until the last available follow up. All patients who

Table 1. Demographic and interventional characteristics of 185 patients with or without distal stent graft induced new entry (dSINE) after thoracic endovascular aortic repair (TEVAR)

Characteristics	Non-dSINE $n = 173$	dSINE $n = 12$	p value
Demographic characteristics			
Age – y	62.9 ± 12.2	60.3 ± 12.2	.47
Men	124 (72)	8 (67)	.77
Acute aortic dissection	71 (41)	6 (50)	.13
Chronic aortic dissection	102 (59)	6 (50)	.67
Interventional characteristics			
Stent graft diameter – mm	34.1 ± 4.7	33.6 ± 2.3	.75
Stent graft length – mm	161.7 ± 41.1	172.0 ± 30.5	.41
Angle – degree	164.3 ± 14.7	150.0 ± 14.9	.001
Taper Ratio Prox TL-dist max – %	9.1 ± 16.5	20.5 ± 12.0	.021
Taper Ratio Prox TL-dist mean – %	24.7 ± 13.0	41.5 ± 14.1	.001
Oversizing PLZ – %	10.0 ± 7.8	9.7 ± 5.5	.90
dOS TL max – %	23.8 ± 11.1	46.7 ± 18.3	.001
dOS TL mean – %	52.1 ± 18.6	93.3 ± 34.7	.001
Re-intervention	34 (20)	10 (83)	.001

Data are presented as mean ± standard deviation (SD) or n (%). dOS = distal oversizing; dSINE = distal stent graft induced new entry; PLZ = proximal landing zone; TL = true lumen.

developed dSINE had a straight, commercially available stent graft implanted in the primary endovascular procedure. None of the patients who received tapered stent grants developed dSINE. In the non-dSINE group ($n = 173$), non-tapered stent grafts had been implanted predominantly ($n = 147$). No custom made stent grafts were used for the primary endovascular procedure. No differences in dSINE development were found in relation to the type of stent graft used.

Predictors of distal stent graft induced new entry development

A smaller angle between the distal end of the stent and the continuation of the aorta, a higher taper ratio, and increased dOS as an expression of the distal stent lumen mismatch were found in the dSINE group. The extent of proximal oversizing was not significantly different between the groups (Table 1). Distal oversizing in the non-dSINE group ranged between 2% and 67% (maximum true lumen [max TL], Fig. 2) and 10—105% (mean TL), whereas the dSINE group showed increased dOS that ranged from 24% to 72% (max TL) and 45% to 144% (mean TL). This difference remained significant even after excluding tapered stent grafts, which are considered to have an impaired dOS (max TL, $p < .001$; mean TL, $p < .001$). No differences in total aortic remodelling were seen comparing dOS of >20% and ≤20% (19 *vs.* 9, $p = .367$).

Subanalysis of tapered *vs.* non-tapered stent grafts showed no differences in angle (164.6 ± 14.5° *vs.* 162.5 ± 16.2°, $p = .226$) or proximal oversizing (9.8 ± 7.1% *vs.* 11.5 ± 11.4%, $p = .261$). Noticeably, tapered stent grafts were more frequently used in cases with higher taper ratios compared with non-tapered stent graft interventions (taper ratio Prox TL - dist max: 7.9 ± 15.3 non-tapered *vs.* 15.8 ± 21.7 tapered, $p = .024$). Although the use of tapered stent grafts was associated with a higher taper ratio, decreased dOS (dOS TL max; 25.7 ± 10.7% *vs.* 12.6 ± 5.7%, $p = .001$) and a lower re-intervention rate (22 *vs.* 4%, $p = .045$) were seen.

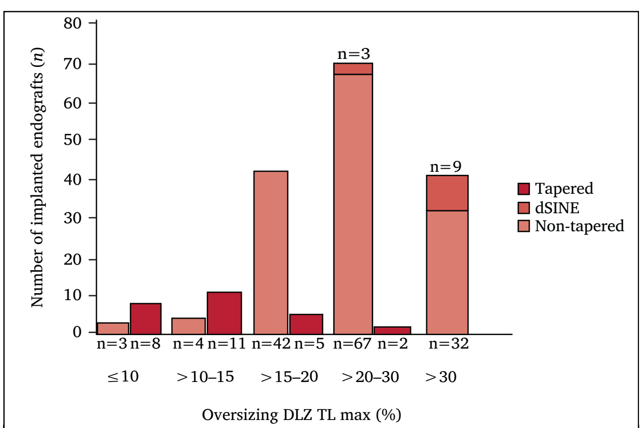

Figure 2. The frequency of distal stent graft-induced new entry increases with over 20% oversizing of the distal landing zone. Image depict all primary endovascular procedures. The grouped distal oversizing refers to the maximum true lumen diameter measured at the presumed distal landing zone before implantation (TL max). The predominant interventional strategy resulted in a distal oversizing of at least 20%. All cases of dSINE were associated with distal oversizing above this threshold (p<.001). Note the reduced distal oversizing associated with tapered stent grafts, with no observation of dSINE. Distal oversizing was calculated as: (stent graft diameter / presumed DLZ diameter before implantation) × 100. dSINE = distal stent graft induced new entry; DLZ = distal landing zone; TL = true lumen.

Binomial logistic regression revealed that the logistic regression model was statistically significant: $\chi^2(5) = 47.631$, $p < .0005$. The model explained 63.7% (Nagelkerke R2) of the variance in dSINE development and correctly classified 97.1% of cases. Sensitivity was 63.6% and specificity was 99.4%. Of the five predictor variables, three were statistically significant: taper ratio, dOS, and acute dissection (Table 2). Increased taper ratio caused a 4.5 fold increase in risk of dSINE, and increased dOS was associated with a 12 fold increased likelihood of dSINE development. Acute dissection was the strongest predictor of dSINE development, associated with a 15.8 fold increase in risk.

Differences between acute and chronic aortic dissection

The most common indication for TEVAR was chronic aortic dissection (108 patients), followed by acute aortic dissection (77 patients). The extent of dOS was significantly higher in chronic aortic dissection compared with acute aortic dissection (Table 3). The use of a tapered stent was similar in both groups (13 *vs.* 11, $p = .181$). Development of dSINE was not significantly different between groups (6 *vs.*6 patients, $p = .543$). Total aortic remodelling was seen by follow up in 27 cases. The rate of total aortic remodelling was significantly higher in chronic aortic dissections compared with acute aortic dissection (22 *vs.* 6 patients, $p = .019$).

Re-intervention after initial development of distal stent graft new entry treatment

Re-intervention was necessary in 45 patients (non-dSINE, $n = 35$; dSINE, $n = 10$) after the primary endovascular procedure. The re-intervention rate was significantly higher in the dSINE group than the non-dSINE group (Table 1). Indications for re-intervention in the dSINE group were mainly dSINE growth ($n = 6$), with a mean size of 21.8 ± 4.6 × 14.5 ± 1.4 mm at initial diagnosis and a mean size of 39.3 ± 3.9 × 26.3 ± 3.9 mm after an early follow up. Three patients underwent re-intervention because of an initial size of dSINE that implied impeding rupture (41.2 × 18.1 mm, 42.0 × 17.9 mm, and 45.5 × 19.4 mm). One patient was treated for intestinal malperfusion (Table 4). Re-intervention was not needed in two patients with only minor disease development and regular serial CTs were observed during follow up. The mean completed follow up after re-intervention was 55.2 ± 50.5 months (range 3.4—159.8 months). After re-intervention, successful treatment of dSINE was observed, including complete sealing of the distal entry without the requirement for

Table 2. Logistic regression analysis for factors associated with distal stent graft induced new entry (dSINE) after thoracic endovascular aortic repair (TEVAR)

Factor	B	SE	Wald	df	*p* value	OR	95% CI
Angle − degree	−0.66	0.38	3.02	1	.082	0.52	0.25−1.10
Taper ratio mean − mm/mm	1.49	0.48	9.66	1	.002	4.477	1.73−11.48
dOS TL mean − %	2.49	0.74	11.20	1	.001	12.04	2.80−51.70
Acute AD − *n*	2.76	1.22	5.09	1	.024	15.80	1.44−173.58
Stent graft length − mm	0.41	0.48	0.71	1	.40	1.50	0.58−3.89
Constant	−10.62	5.40	3.86	1	.049	0.00	

AD = aortic dissection; dOS = distal oversizing; dSINE = distal stent graft induced new entry; TL = true lumen. For continuous variables, OR values were calculated per unit change; CI = confidence interval; OR = odds ratio; SE = standard error; degrees of freedom; Wald = Wald test; B = beta coefficient.

further re-intervention in seven patients. One patient developed a new type I endoleak because of a fractured distal stent graft that did not require re-intervention until the last follow up (69 months); one patient developed a new endoleak after 9.6 months that required re-intervention, which the patient refused and ceased to attend further follow up visits. Another patient was lost to follow up after 8.4 months.

The results of Kaplan—Meier survival analysis are illustrated in Fig. 3. Patients who developed dSINE had a mean time to re-intervention of 27.7 months (95% CI 13.5—42.0 months). This was dramatically shorter than the time to re-intervention in the non-dSINE group, which was 128.4 months (95% CI 119.3—137.5 months). Log rank test analysis revealed that the levels of freedom from re-intervention were significantly different between the groups: $\chi^2(1) = 52.319$, $p < .0005$.

DISCUSSION

This study found three major predicting factors for dSINE development: acute aortic dissection, increased dOS, and increased taper ratio. Two of these have been identified previously as risk factors for dSINE development,[8,12,13] but data regarding any differences between acute and chronic dissections are lacking.

A 6.5% incidence of dSINE is reported, which is in line with previous reports,[7,8,14] although the range of previously observed incidence rates shows significant variation, from 3% to 28%.[6,7,15—18] The low incidence rate observed can be attributed to the use of tapered stent grafts, which accounted for almost a fifth of the stents used in this study and these were not associated with any dSINE development.

The size mismatch between the distal aorta and the stent graft is key in the aetiology of dSINE, although the contrast between the delicate aortic vessel wall and the rigid stent graft end contributes. The size mismatch from oversizing represents the strongest risk factor for dSINE development. Increased dOS and taper ratios are independent risk factors, both of which indicate aorta/stent graft mismatch. The aim was to identify a threshold value for the risk of dSINE development. Multivariable analysis revealed that every 1% increase in the value of the taper ratio caused a 4.5 fold increase in dSINE development. Furthermore, when dOS exceeded 20%, dSINE could be detected.

When tapered stent grafts were used (26 of 173 cases), dOS exceeded 20% in only two patients. The use of tapered stent grafts decreases dOS by up to 50%, and therefore may reduce the risk of dSINE. Nevertheless, the 4 mm tapered end of the most commonly available tapered stent grafts results in an increased discrepancy between PLZ and DLZ,[18,19] as evidenced by the higher taper ratio in the tapered stent cohort. Therefore, custom made tapered stent grafts were used in several cases of dSINE re-intervention for the small distal true lumen.

The pathological fragility of the aortic wall is another important aspect in assessment of dSINE risk factors. Aortic stiffness in the stented aortic segment was found to be almost double the original value after TEVAR, which increases strain intensity in the non-stented area. Strain causes alterations that can result in mechanical stress, causing dSINE which leads to pseudoaneurysm.[8,20,21] This is seen especially at the transition zones between the rigid stent graft and the fragile aortic wall. The dissection membrane of acute dissections is approximately 15 times more prone to dSINE development compared with that of chronic dissections, and might therefore be at particular risk.[17] Although the pathogenesis of aortic dissections is not fully understood, medial weakness and degeneration of the vasa vasorum seem to play key roles in acute aortic

Table 3. Stent graft and interventional characteristics between acute and chronic aortic dissection (AD)

Characteristics	Acute AD *n* = 77	Chronic AD *n* = 108	*p* value
Angle − degree	163.7 ± 14.5	162.3 ± 16.7	.56
Taper Ratio Prox TL-dist max − %	9.8 ± 16.4	9.2 ± 16.4	.80
Taper Ratio Prox TL-dist mean − %	26.1 ± 13.6	25.3 ± 13.2	.70
Oversizing PLZ − %	9.8 ± 8	9.5 ± 7.1	.81
dOS TL max − %	19.7 ± 10.8	29.4 ± 13.6	.001
dOS TL mean − %	50.1 ± 24	58.7 ± 21.3	.011

Data are presented as mean ± standard deviation (SD). AD = aortic dissection; dOS = distal oversizing; PLZ = proximal landing zone; TL = true lumen.

Table 4. Re-interventions in the distal stent graft induced new entry group

Patient no.	Reason for re-intervention	Stent graft type	Stent graft size, mm	FU since re-intervention, mo	Time between diagnosis and re-intervention, mo	Freedom from dSINE or other reason for re-intervention
I	Impeding rupture	Bolton Relay	32×200	105.6	0.2	Yes
II	dSINE growth	Talent (2x)	38/34×150	159.8	0.9	Yes
III	dSINE growth	Bolton Relay	36×28×160	3.4	0.3	Yes
IV	dSINE growth	Valiant	32×28×150	94.0	1.6	Yes
V	Impeding rupture	GORE TAG	37×150	24.7	2.5	Yes
VI	dSINE growth	Valiant	30×120	21.9	2.1	Yes
VII	dSINE growth	Bolton Relay	34×22×150	9.6	3.8	No, re-re-intervention needed because of endoleak, patient denied
VIII	Malperfusion	Bolton Relay	36×26×170	8.4	2.2	Yes, but lastly lost to FU
IX	Impeding rupture	Bolton Relay	34×30×145	69.0	2.7	Distal stent graft fractured, intensified FU
X	dSINE growth	Bolton Relay	34×30×140	59.0	1.5	Yes

dSINE = distal stent graft induced new entry; FU = follow up; mo = months.

dissection development,[22–24] which results in a fragile intimal layer. This layer may be particularly at risk of dSINE during the remodelling mechanisms that result in acute aortic dissection. Further chronicity of aortic dissection includes changes in intimal thickening, decreased intimal flap motion with flap straightening over time, and a tendency to a straighter and thicker flap,[25,26] which might be less vulnerable to dSINE.

The aortic dissection membrane exhibits substantial changes over the transition of the disease from acute to chronic, which includes the subacute stage (two weeks to three months). The subacute transition zone is characterised first by transformation mechanisms, including intimal hyperplasia with flap thickening and a reduction in elasticity[25] as a preliminary stage of chronicity. The histopathological changes produce similarities to chronic dissection membranes, which may explain the similar behaviour observed for dSINE development in the present study.

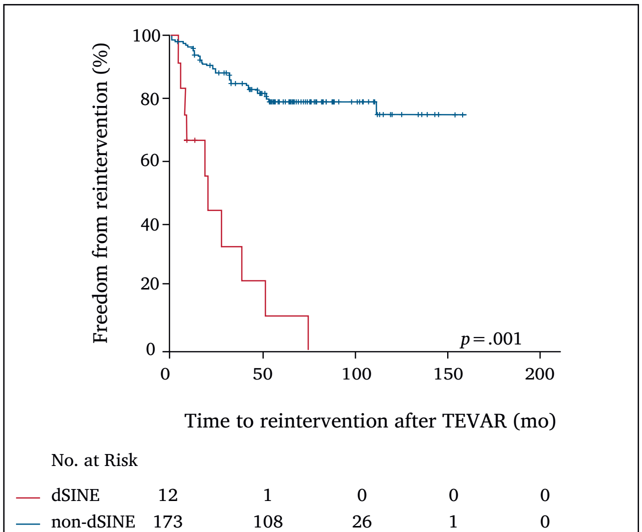

Figure 3. Cumulative Kaplan-Meier survival estimate of time to re-intervention after thoracic endovascular aortic repair. Graphs illustrate data of patients who required re-intervention after thoracic endovascular aortic repair (TEVAR) with or without development of distal stent graft induced new entry (dSINE). mo = months.

Ten of the 12 patients with dSINE needed re-intervention, whereas the two patients with minor dSINE and those without progression only required blood pressure control and intensified follow up visits. To the best of the present authors' knowledge, this is the first time that long term results for dSINE patients after re-intervention (with a mean follow up of more than four years) have been reported. Satisfying results are presented after re-intervention for most of the available patients, comparable to chronic type B aortic dissections after TEVAR.[27] In the rare case of dSINE development, optimal surveillance and/or re-intervention are key in the successful treatment of dSINE and avoidance of disease progression. Because dSINE is associated with an increased risk of rupture and mortality,[7] long term surveillance is crucial. In the present study, patients in the non-dSINE group were treated mainly because of malperfusion, which may be attributable to the rate of sub-acute dissections ($n = 16$, 44% of patients treated with malperfusion) and recruitment of patients from a major tertiary referring centre.

The present study has some limitations that must be taken into account. One major limitation arises from the small cohort and low prevalence of dSINE. Another limitation is the lack of intra- or interobserver assessment. However, measurements of proximal oversizing, TR, dOS, and stent graft/aorta angle were performed by a single investigator, who was blinded to the study details. The lack of a standardised measurement protocol also represents a limitation. To address this, the same experienced radiologist always performed angle assessments in the same manner. Moreover, it should not be ignored that patients with severe disease progression may die before dSINE can be detected, and therefore bias the study results. This bias is not negligible. Attempts were made to minimise delayed detection of dSINE or other stent graft pathologies in the early phase after stent graft implantation using an intensified follow up protocol during the first year after TEVAR (visits including CTA after one, three, six, and 12 months). It is possible that the grade of oversizing used for re-intervention in the dSINE group might have influenced the long term results. As a result of the small number of treated patients, no generalisations can be made. Attempts were made to minimise dOS during re-intervention as far as possible using tapered or custom made stent grafts, and further studies are needed to evaluate the ideal balance between proximal and dOS to avoid stent graft related complications.

CONCLUSIONS

The presence of dSINE is associated with increased risk of aortic rupture and, therefore, requires lifelong surveillance. Some risk factors have been identified in previous studies, but dOS in particular was revealed to be an independent risk factor in the present study. Especially in the case of acute aortic dissection, dOS should be reduced as far as possible to relieve the vulnerable acute aortic dissection membrane. The use of tapered stent grafts might be beneficial in some instances. In the rare case of dSINE occurrence, even when re-intervention is required, the prognosis remains good for many years.

CONFLICT OF INTEREST

None to declare.

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COUP D'OEIL

Brachial Artery Mycotic Aneurysm After Pneumococcal Pneumonia

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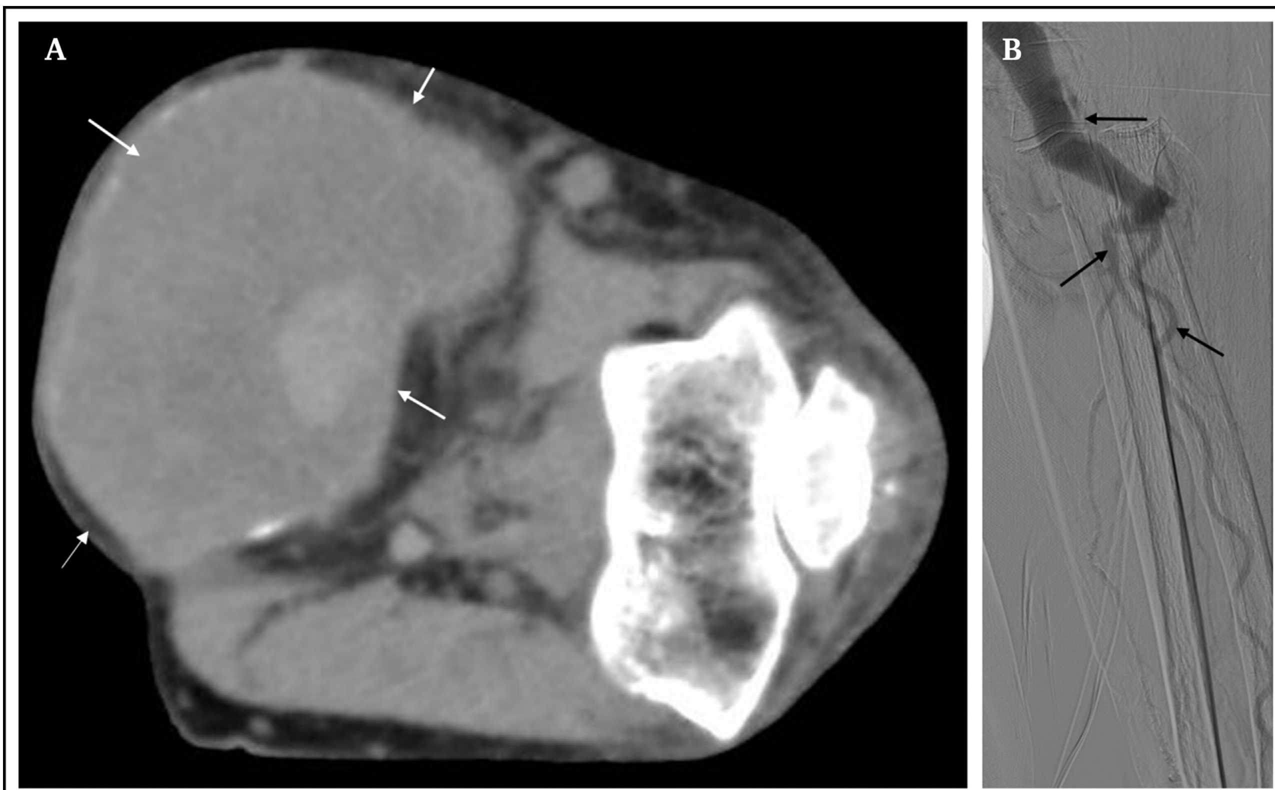

A 73 year old man who had renal transplantation for end stage renal disease and left brachiocephalic arteriovenous fistula ligation five years previously (due to a symptomatic venous aneurysm) was admitted with pneumococcal pneumonia. The patient presented with a spontaneous large pulsatile left arm mass without cutaneous inflammatory or acute ischaemia signs. Computed tomography angiography (A) showed a brachial artery aneurysm measuring 59 mm with contrast dilution obscuring runoff artery detail. Supplementary digital subtraction angiography revealed patent brachial, ulnar, and radial arteries (B, arrows). Aneurysm resection and axillobrachial bypass with autologous great saphenous vein was performed. Brachial artery microbiological examination revealed gram positive cocci.

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