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ORIGINAL ARTICLE

The location of the primary entry tear in acute type B aortic dissection affects early outcome†

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Abstract

OBJECTIVES: The goal of the retrospective study was to relate the site of the primary entry tear in acute type B aortic dissections to the presence or development of complications.

METHODS: A consecutive series of 52 patients referred with acute type B aortic dissection was analysed with regard to the location of the primary entry tear (convexity or concavity of the distal aortic arch) using the referral CT scans at the time of diagnosis. These findings were related to the clinical outcome as well as to the need for intervention.

RESULTS: Twenty-five patients (48%) had the primary entry tear located at the convexity of the distal aortic arch, whereas 27 patients (52%) had the primary entry tear located at the concavity of the distal aortic arch. Twenty per cent of patients with the primary entry tear at the convexity presented with or developed complications, whereas 89% had or developed complications with the primary entry tear at the concavity ($P < 0.001$). Furthermore, in patients with complicated type B aortic dissection, the distance of the primary entry tear to the left subclavian artery was significantly shorter as in uncomplicated patients (8 vs. 21 mm; $P = 0.002$). In Cox regression analysis, a primary entry tear at the concavity of the distal aortic arch was identified as an independent predictor of the presence or the development of complicated type B aortic dissection.

CONCLUSIONS: A primary entry tear at the concavity of the aortic arch as well as a short distance between the primary entry tear and the left subclavian artery are frequently associated with the presence or the development of complicated acute type B aortic dissection. These findings shall help us to further differentiate acute type B aortic dissections in addition to the common categorization in complicated and uncomplicated. These findings may therefore also have an impact on primary treatment.

Keywords: Type B aortic dissection • Primary entry tear • TEVAR

AORTIC SURGERY

INTRODUCTION

In the current era, patients with uncomplicated type B aortic dissections are usually treated medically. However, despite significant advances in diagnosis and treatment, the management of acute type B aortic dissection remains controversial and decision-making is based on subjective clinical judgment [1–3]. Both surgical and interventional therapies are considered treatment options of choice in cases of complicated type B dissection. Owing to the rapid advances of thoracic endovascular aortic repair (TEVAR), this treatment option has been established in the armamentarium of cardio-thoracic surgeons. Lately, evidence has shown its superiority as the treatment of choice for complicated type B aortic dissection [4, 5]. To date in the overwhelming majority of cases, the location of the primary entry tear is not yet taken into consideration during the course of determining the treatment strategy. However, previous work has shown some evidence that an entry tear located at the concavity may be associated with a complicated follow-up of an acute type B aortic dissection, including the catastrophic expansion into the ascending aorta [6, 7].

The goal of the retrospective study was to relate the site of the primary entry tear in acute type B aortic dissections to the presence or development of complications.

METHODS

A database search has been performed retrospectively to identify all patients with acute type B aortic dissection between 2005 and 2011 in two institutions (University Hospital Berne and

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Table 1: Descriptive characteristics of the entire cohort

	n, overall = 52
Demographics	
Age, mean (SD)	61 (12)
Female, *n* (%)	5 (10)
Dissection entry site	
Concave, *n* (%)	27 (52)
Convex, *n* (%)	25 (48)
Aortic morphology assessed by MSCT	
Distance to LSA (mm), median (IQR)	15 (0–25)
Diameter descending aorta (mm), median (IQR)	37 (33–40)
True lumen diameter (mm), median (IQR)	17 (13–31)
False lumen diameter (mm), median (IQR)	20 (15–25)
Diameter abdominal aorta (mm), median (IQR)	30 (27–33)
True lumen diameter (mm), median (IQR)	12 (7–17)
False lumen diameter (mm), median (IQR)	18 (13–24)
Indication for treatment	
Complicated, *n* (%)	29 (56)
Overall need for intervention, *n* (%)	36 (69)
Time to intervention in days, mean (range)	4 (0–14)
Outcome	
Retrograde type A dissection, *n* (%)	2 (4)
Mortality, *n* (%)	2 (4)

SD: standard deviation; IQR: inter-quartile range.
Unless otherwise indicated, data are numbers (percentages).
Primary complicated indicated by occurrence of retrograde dissection, malperfusion or impending rupture.

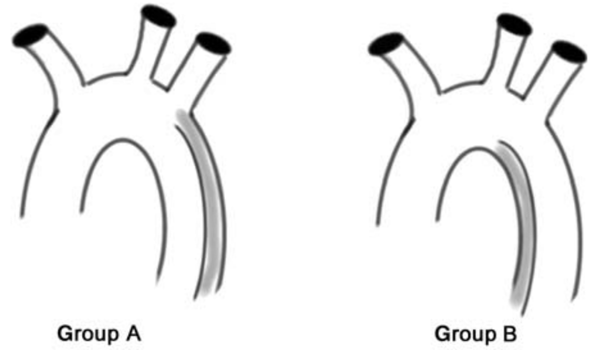

Figure 1: Scheme of different sites of the primary entry tear of acute type B aortic dissections. (**A**) Primary entry tear at the outer circumference of the distal aortic arch defined as 'convex'. The retrograde component of the dissection is stopped by left subclavian artery. (**B**) Primary entry tear at the inner circumference of the distal aortic arch defined as 'concave', allowing progression of the retrograde component of the dissection into the aortic arch and the ascending aortas.

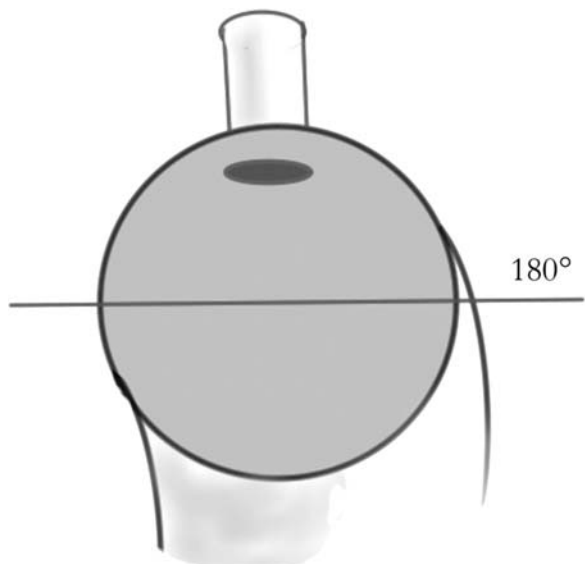

Figure 2: Scheme of stratification regarding concavity and convexity of the distal aortic arch.

Hospital Hietzing Vienna). Fifty-two patients referred with acute type B aortic dissection who had a multi-slice CT angiography of the entire aorta at the time of diagnosis were identified and analysed. Patient demographics are shown in Table 1. No patients with known or suspected connective tissue disease have been included in the study.

Definition of acute type B aortic dissection

Acute type B aortic dissection was defined as an aortic dissection with a primary entry tear at the level of the left subclavian artery or distal to the left subclavian artery [8].

Definition of complicated and uncomplicated acute type B aortic dissection

Complicated acute type B aortic dissection was defined as rupture, contained rupture, including progressive pleural effusions, retrograde extent into the arch or into the ascending aorta, furthermore visceral, renal or limb malperfusion, and/or persistent pain [9].

Morphometric definitions

Patients were stratified according to the location of the primary entry tear. On axial CT scans, primary entry tears at the upper circumference (180°) of the distal aortic arch were defined as to be at the convexity, and the remaining as to be at the concavity (Figs 1 and 2). Morphometric measurements also included the distance from the primary entry tear to the left subclavian artery. Furthermore, diameters of the lumina—both true and false—of the thoracic and abdominal aorta were measured.

Statistical methods

Continuous data are presented as the median and the interquartile range (range from the 25th to the 75th percentile) or as the mean and the standard deviation (SD), as appropriate. Discrete data are given as counts and percentages. Comparisons of continuous data were performed by the Mann–Whitney *U*-test and groups of categorical data were compared by Fisher's exact tests. Univariate Cox regression analysis was primarily performed to assess the prognostic impact of the dissection's site upon the future development of complications, followed by a multivariate Cox regression to adjust for a pre-existing retrograde component of the dissection and the distance of dissection entry to the left subclavian artery in quartiles. Results of the regression model are given as the hazard ratio (HR) and the 95% confidence interval (95% CI). Regression diagnostics and overall model-fit were performed according to standard procedures. A two-sided *P*-value <0.05 was considered statistically significant. Calculations were performed with SPSS for Mac OsX (version 19.0).

RESULTS

Demographics

The mean age of all patients was 61 ± 12 years, five patients (10%) of the entire study population were females.

Clinical outcome

Out of the entire study population of 52 patients, 36 patients (69%) underwent intervention for complicated acute type B aortic dissection. Patients with a primary entry tear at the concavity presented with a significantly higher incidence of complicated acute type B aortic dissection during the entire hospital stay (convexity, 20% vs. concavity, 89%; *P* = 0.001). There was also a significant difference between the groups concerning the incidence of primary complicated type B aortic dissection at admission (convexity, 12% vs. concavity, 48%; *P* = 0.005) (Table 2). Correspondingly, overall need for intervention was significantly higher in the concave group compared with the convex group (convexity, 38% vs. concavity, 100% *P* = 0.001). Mortality was 4% due to multiorgan failure as a sequelae of the underlying aortic disease. In two other cases, a retrograde type A dissection occurred immediately after TEVAR. These two patients were converted into open surgery and treated with the frozen elephant trunk technique with successful clinical outcome. The remaining patients had an uneventful aortic-related clinical course.

Table 2: Distribution of patients by different chronic health conditions and in-hospital risk assessment stratified to the origin of the primary dissection entry

	Concave (*n* = 27) vs. convex (*n* = 25)		*P*-value
Demographics			
Age, mean (SD)	59 (12)	62 (11)	0.37
Female sex, *n* (%)	2 (7)	3 (12)	0.53
Aortic morphology assessed by MSCT			
Distance to LSA (mm), median (IQR)	8 (8–10)	21 (7–30)	0.002
Diameter descending aorta (mm), median (IQR)	37 (33–41)	37 (33–40)	0.95
True lumen diameter (mm), median (IQR)	17 (12–23)	17 (13–20)	0.89
False lumen diameter (mm), median (IQR)	20 (16–26)	20 (15–24)	0.64
Diameter abdominal aorta (mm), median (IQR)	31 (27–34)	29 (27–33)	0.46
True lumen diameter (mm), median (IQR)	11 (4–16)	14 (11–17)	0.09
False lumen diameter (mm), median (IQR)	20 (13–28)	16 (13–19)	0.08
Indication for treatment			
Complicated, *n* (%)	24 (89)	5 (20)	<0.001
Primary complicated, *n* (%)	13 (48)	3 (12)	0.005
Overall need for intervention, *n* (%)	27 (100)	9 (38)	<0.001
Outcome			
Retrograde type A dissection, *n* (%)	1 (4)	1 (4)	0.96
Mortality, *n* (%)	2 (7)	0 (0)	0.17

SD: standard deviation; IQR: inter-quartile range.
Unless otherwise indicated, data are numbers (percentages).
Primary complicated defined by occurrence of retrograde dissection, malperfusion or impending rupture.

Morphological outcome and measurements

Twenty-five patients (group A) had the primary entry tear at the convexity, 27 patients (group B) had the primary entry tear at the concavity (Figs 3 and 4), of the distal aortic arch. There was a significant difference between the two groups with regard to the distance to the left subclavian artery (group A, 21 ± 15 mm vs. group B, 8 ± 12 mm; *P* = 0.002). Retrograde progression of the dissection was more common in the concave group than in the convex group (group A, 36% vs. group B, 52%; *P* = 0.25). Finally, false lumen diameter at the mid-thoracic level was larger in patients with the primary entry tear located at the concavity vs. the convexity group (group A, 16 ± 5 mm vs. group B, 20 ± 8 mm, *P* = 0.08).

Need for intervention

There was a significant difference between the groups with regard to the incidence of primary complicated acute aortic type B aortic dissection (convexity, 12% vs. concavity, 48%; *P* = 0.005). Furthermore, patients with a primary entry tear at the concavity were more likely to develop complications within the first 72 h than patients with a primary entry tear at the convexity (convexity, 7 days vs. concavity, 3 days; *P* = 0.06) (Fig. 5). For the origin of the dissection at the convexity, freedom from development of complicated dissection was 80% at 7 days, 71% at 14 days and 63% at 21 and 28 days. For the origin of the dissection at the concavity, freedom from development of complicated dissection was 30% at 7 days and 13% at 14 days.

Cox regression analysis

Cox regression analysis revealed a primary entry tear at the concavity of the distal aortic arch as an independent predictor for the presence or the development of complicated acute type B aortic dissection (Table 3).

DISCUSSION

The median age of our cohort corresponded well to recently published series [10, 11]. Interestingly, the number of females in this cohort was lower than in other cohorts of acute type B aortic dissection [12]. The incidence of complicated acute type B aortic dissection was higher than in the recent literature [13].

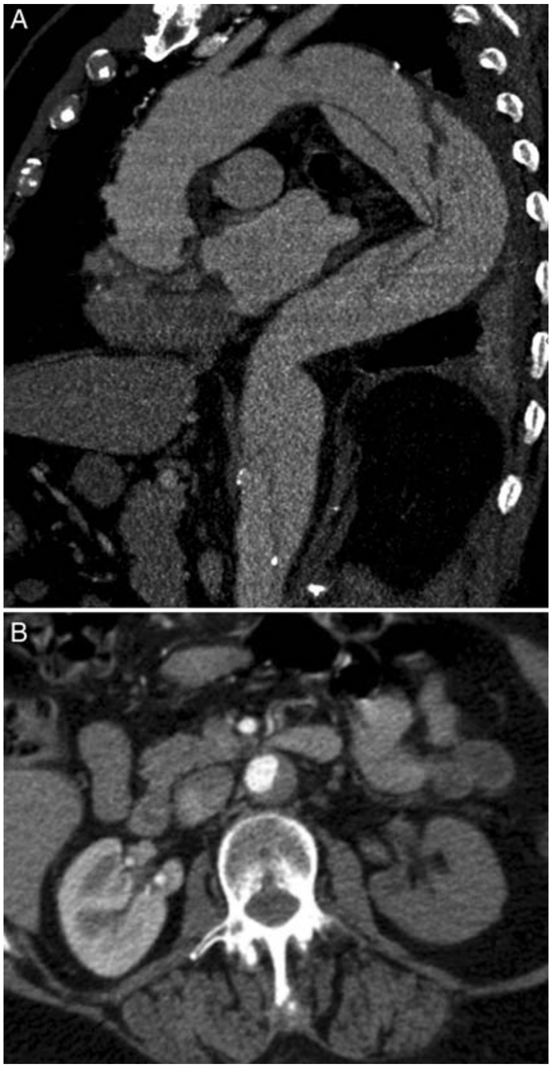

Figure 3: A 75-year old male patient with a malperfusion syndrome of the left kidney. (**A**) Parasagital CT angiographic image showing an acute type B aortic dissection with a primary entry tear at the concavity of the distal aortic arch. (**B**) Axial image of the same patient at the level of the renal arteries showing a massive compression of the true lumen with subsequent malperfusion of the left kidney.

Figure 4: Fluoroscopy of a 58-year old male patient with a type B aortic dissection and the primary entry tear on the convexity of the distal aortic arch.

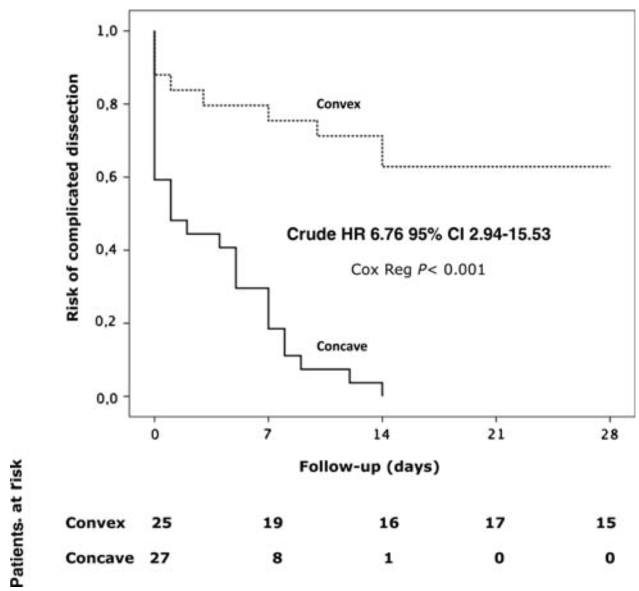

Figure 5: Kaplan–Meier calculation of time to intervention for both groups showing significant differences in the time to intervention related to the site of the primary entry tear.

These findings warrant further attention. The incidence of complicated acute type B aortic dissection is reported to be 10–18% [14]. In our series, the incidence of primary complicated acute type B aortic dissections is 56%. We feel that the incidence of complicated type B aortic dissection might be underreported due to several reasons. Patients are classified as uncomplicated due to the absence of clinical signs of complications, such as malperfusion, haemodynamic compromise and pain and may therefore be discharged from hospital early. In our series, the time to development of complications was different with respect to the location of the primary entry tear. Interestingly, complications, such as malperfusion and recurring pain, occurred within the first 14 days with diminishing frequency with regard to the time of the initial event, but not afterwards [15–17]. Indications for intervention afterwards were due to diameter increase but not due to classical indications [18]. Therefore, hospitalization of patients with acute type B aortic dissection can be recommended for 14 days as the probability for development of classical complications afterwards is low. The incidence of retrograde type A aortic dissection was comparable with recently published series [19]. However, retrograde type A aortic dissection is not limited to the peri-interventional time period and may also happen years after treatment [20]. As such, the need of stent-grafts especially for the treatment of acute and chronic aortic dissections is not sufficiently met by the industry as compliance mismatch between the very elastic aortic wall and the rigid graft and the resulting shear stress might well be causative for this phenomenon. Furthermore, the morphologically normal ascending aorta as well as the aortic wall may well be inheritably diseased and thereby prone to dissection.

There was a significant difference with regard to the occurrence of complications with regard to the location of the primary entry tear. Patients with a primary entry tear at the

Table 3: Predictors of complicated dissection—Cox regression analysis

	HR	95% CI	*P*-value
Risk factor			
Concave	7.26	3.03–17.36	<0.001
Retrograde component	1.44	0.73–2.85	0.29
Distance to subclavian artery (in quartiles)	0.96	0.70–1.32	0.81

concavity were by far more likely to already present with complicated acute type B aortic dissection or to develop complications within the first 72 h after the initial event. Interestingly, the distance from the primary entry tear to the left subclavian artery was significantly shorter in patients with complicated acute type B aortic dissection. This finding warrants discussion. We hypothesize that haemodynamics and consequently pressure gradients in both lumina are affected by this morphological detail, leading to a higher pressurization of the false lumen due to the steeper angulation of the aortic arch at the level of the left subclavian artery. However, this theory has to be verified by further experimental and clinical work.

The need for intervention in this study was high and evidently corresponded to the high percentage of complicated type B aortic dissection. The primary strategy of intervention is closure of the primary entry tear in order to decompress the true lumen, restore distal perfusion by expanding the true lumen and finally, to stabilize segments with impending rupture. In the majority of cases, the domino effect of readaption of the dissection membrane to the adventitia can be accomplished with the closure of the primary entry tear by TEVAR. However, in specific situations, the domino effect might be impaired by additional rupture of the membrane below the stent-graft or by a large communications between the lumina, thereby prohibiting effective decompression of the true. In these situations, surgical membrane fenestration might be an option in addition to TEVAR or even as a sole therapeutically approach.

Cox regression analysis revealed the location of the primary entry tear at the concavity of the distal aortic arch as the sole independent predictor of the presence or the development of acute type B aortic dissection. This finding represents the core statement of this study as morphology regarding the location of the primary entry tear was not taken into consideration to date. As such, this detail might represent an adjunct in the armentarium of the treating physician to stratify patients being at risk for complications and thereby anticipating the need for intervention.

Limitations of the study

It is clear that distribution patterns of the exact location of the primary entry tear do not adhere to geometrical algorithms and that a certain variability is present. We are fully aware of this problem and have therefore stratified used a clear definition of what we regarded as concavity and what we regarded as convexity namely on axial CT scans, primary entry tears at the upper circumference (180°) of the distal aortic arch were defined as to be at the convexity, and the remaining as to be at the concavity. Interestingly, there few cases where we had doubt how to stratify these patients due to the fact that the entry was located exactly on the lateral wall. So it seems that to be that the natural occurrence of primary entry tears is associated with a clear correlation to one or the other circumference. Regarding the distance to the left subclavian artery, some self-criticism has to be applied as the angulation of the aortic arch has to be taken into account to a certain extent. In order to keep comparability, we adhered to a strict perpendicular measurement. We feel that simplification is a major component of a better understanding of diseases whose underlying pathomechanisms have not been fully understood. As such, this simplified delimitation of a highly complex problem is vital. We do hope that these investigations will stimulate others to go in the same direction and consequently future work will confirm our findings or will put them into question.

Clinical relevance of the study

The clinical relevance of this study lies in increasing the awareness for surrogates of complications which have not been addressed to date. It is clear that these findings have no additive value in a patient being referred with already sustained complications, but it helps to understand why it has happened. Furthermore, as has been pointed out in this study, there are patients with a primary entry tear at the concavity who are asymptomatic at the time of referral and who will develop complications within the first week after the acute event. Therefore, the additive value of this report lies in the newly created awareness of this subgroup at risk. As a consequence, we suggest liberal endovascular treatment in patients with this specific risk constellation of a primary entry tear at the concavity and a short distance to the left subclavian artery in order to prevent a very high probability of complications, especially malperfusion or retrograde type A aortic dissection.

Summarizing, a primary entry tear at the concavity of the aortic arch as well as a short distance between the primary entry tear and the left subclavian artery are frequently associated with the presence or the development of complicated acute type B aortic dissection. Based on these findings, the localization of the primary entry should be implemented in risk stratification of acute type B aortic dissection in addition to the common categorization in complicated and uncomplicated. These findings may therefore also have an impact on primary treatment.

Conflict of interest: none declared

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APPENDIX. CONFERENCE DISCUSSION

Dr M. Grimm *(Vienna, Austria)*: The paper studies the hypothesis that an initially uncomplicated type B dissection starting at the concavity of the arch is significantly at risk of developing early complications within the subsequent few days, and I think this is, in the clinical setting, an extremely important period. In contrast (and this has to be discussed I think), if the tear is located in the convexity, the risk of early complications is low.

If you follow this theory, this has potentially life-saving but also life-threatening implications for the patient. Therefore I have three important questions I want to ask you. Firstly, I personally find it extremely difficult in a certain number of cases to identify the exact location of the primary entry tear. And given the scenario that maybe a less experienced radiologist and less experienced surgeons are on call late at night, do you think that an exact identification of the entry tear at the primary CT scan is really that reproducible for all of us?

Secondly, does identification of the location of the primary entry tear in your opinion have different consequences? So maybe at the convexity, intervention by stent graft placement? Whereas primary entry tear at the concavity, due to the risk of retrograde type A dissection, has the consequence of surgical intervention?

And thirdly, could you share your opinion with us? Which types of stents do you use in such cases, because early intervention in acute type B dissection carries a high risk of retrograde type A dissection.

Dr Weiss: As you know, I am not an expert on imaging, which is one reason why it was a retrospective study. We asked a radiologist, expert in aortic pathologies, to help with the evaluation of the CT scans and, together with Martin Czerny, who has a great experience in aortic dissections, we were able to analyse the CT scans and precisely define the location of the primary entry tear.

I believe that not every radiologist is able to do this analysis precisely, and an expert in aortic pathologies is definitely needed. I think in a late night setting, it may be difficult to find an experienced radiologist who is able to exactly locate the primary entry. Maybe you will be able to get expert help to assist with this aspect in the morning. Coming to the second question, I believe that it is too early to say that if the primary entry is located at the concavity of the distal aortic arch you should implant a stent graft or not. I think more work needs to be done in this area, and we will need more patients to clarify this question. I would not recommend doing an intervention just because the primary entry tear is located at the concavity of the distal aortic arch.

And the third question, we mainly used a stent graft with uncovered bare springs, but I think that we should reconsider this treatment approach in the future due to our high incidence of retrograde type A dissections after stent graft placement for type B dissection.

Dr E. Mostafa *(Cairo, Egypt)*: There is actually a classification, which is most probably unknown, but I guess Jean Bachet knows it; a classification or first classification for type A dissection taking into consideration the multiple entries. My question to your group is, do you consider the multiple entries, not one single primary entry, as risk factors for complications?

Dr Weiss: I am sorry. I did not really understand the question.

Dr Mostafa: Multiple entries, because actually we have been speaking about one single primary entry which I guess is not so common. The most common cause for complications is actually the missed, undiagnosed multiple entries, and probably Jean Bachet can support this, according to their classification or first classification.

Dr Weiss: Well, we detected first the primary entry tear and did not really concentrate on the multiple re-entries in this study. We tried to find the exact site of the primary entry, and if these patients needed an intervention for complicated.

Dr Mostafa: I mean primary entries, entries, not one.

Dr M. Grabenwöger *(Vienna, Austria)*: One is always the first. You have multiple entries, but one is the first one.

Dr Weiss: Yes. But I guess the most common cause of complications is the missed multiple entries after that one which is very evident to us.

Dr M. Czerny *(Berne, Switzerland)*: I think it is clear that the number of communications between both lumina has an impact, but our impression is that it does not have an impact on the development of complications. It has an impact on the development of late aneurysmal formation, but we were not able to find an association. And the other thing is that it is extremely difficult to visualize, let's say to count the number of communications in the proximal thoracic aorta on the CT scan. I think for this we need functional imaging, and this should be the next step.

Dr A. Rajaii-Khorasani *(Mashhad, Iran)*: Did you analyse the length of the aorta, meaning aortas as in the CT scan that you show, which is a torturous, elongated aorta?

Dr Weiss: I know, but we did not include the length of the aorta in our analysis. We just measured the lumen diameters and not the length, or if the aorta was kinked or not.

Dr Rajaii-Khorasani: I believe there is no data on this subject in the literature.

Dr Weiss: I agree with you.

Dr Rajaii-Khorasani: But based on my own experience, which is, I believe, an anecdote, the length of aorta is also a pathological sign. Everybody talks about the diameter. Even in the ascending aorta, if you are doing a simple coronary bypass and you see an elongated aorta, these are the ones that may dissect with partial clamping. These are the ones that may bleed from the site of cannulation. This is my experience. So I think if you look at the length of this aorta, it may have some significance.

Dr Czerny: I think this was a very important comment. I am sorry, we have to cut the discussion because we are running late. Maybe you could be so kind to discuss it later on during the break.