How to Guide Stent-Graft Implantation in Type B Aortic Dissection?

Comparison of Angiography, Transesophageal Echocardiography, and Intravascular Ultrasound

Dietmar H. Koschyk, MD; Christoph A. Nienaber, MD; Malgorzata Knap, MD; Thomas Hofmann, MD; Yskert V. Kodolitsch, MD; Valeria Skriabina, MD; Mohammed Ismail, MD; Olaf Franzen, MD; Tim C. Rehders, MD; Christoph Dieckmann, MD; Gunnar Lund, MD; Hermann Reichenspurner, MD; Thomas Meinertz, MD

Background—Despite growing interest in stent-graft implantation for type-B aortic dissection, there are no established recommendations to prepare and perform an implantation procedure.

Methods and Results—We directly compared angiography (ANGIO), transesophageal echocardiography (TEE), and intravascular ultrasound (IVUS) intraprocudurally before and after placement of 48 stent grafts in 42 consecutive patients (12 women, 61 ± 11 years of age) with acute and chronic type-B aortic dissection for both usefulness and capability to guide aortic stent-graft implantation. Both IVUS and TEE are superior to ANGIO to identify multiple entries (52 and 43 versus 34; \( P < 0.005 \) each), to diagnose false-lumen slow flow after stent-graft implantation (32 and 31 versus 24; \( P < 0.005 \) each) and to detect incomplete stent apposition (18 and 16 versus 8; \( P < 0.005 \) each). In comparison with ANGIO, guide wire position over the entire length of the aorta was documented more frequently by TEE and IVUS (40 and 42 versus 25; \( P < 0.001 \) each). In 4 patients with abdominal extension of the dissection, only IVUS was able to accurately identify the false lumen over the entire length of the diseased aorta. TEE was superior to IVUS and ANGIO in the detection of endoleaks (5 versus 0 and 1; \( P < 0.05 \) each). Intraprocedural ANGIO, TEE, and IVUS had been performed without complications in all patients.

Conclusions—TEE in conjunction with ANGIO appears to be advantageous and adds incremental information to safely guide stent-graft placement in type-B aortic dissection. Additional use of IVUS was found to be helpful in patients with complex anatomy and abdominal extension of the dissection. (Circulation. 2005;112[suppl I]:I-260–I-264.)

Key Words: aorta ■ aneurysm ■ angiography ■ echocardiography

Endovascular stent-graft placement is an alternative treatment for aortic type-B dissection. Short-term results for stent-graft repair of acute thoracic aortic dissection are excellent, but long-term outcomes are yet not well assessed.1,2 Despite an increasing number of stent-graft implantsations, the imaging guidance of an implantation procedure is not precisely defined and is the subject of ongoing discussion.3 We compared intraprocudural angiography (ANGIO), imaging by transesophageal echocardiography (TEE), and intravascular ultrasound (IVUS) for their capability to safely guide stent-graft placement in type-B aortic dissections.

Methods

Patients
We compared ANGIO, TEE, and IVUS intraprocudurally before and after the implantation of 48 stent grafts in 42 patients (12 women, 30 men, 61 ± 12 years of age). All of the patients had stable type-B aortic dissection; 34 patients were not pain free under multiple antihypertensive medications; 8 patients had significant progression of the disease. The predominant risk factor was hypertension diagnosed in 35 patients (83%). All of the patients fulfilled the criteria for surgical treatment of either dissection or aneurysm, such as recurrent episodes of thoracic pain, sustained false lumen flow, and a minimum aortic diameter of 5.5 cm with a tendency to enlarge.1,2 Written informed consent was obtained from every patient, which included an explanation about alternative options, such as surgery and medical treatment. The total aortic diameter (true and false lumen) ranged between a minimum of 30.2 ± 7.2 mm and a maximum of 46.1 ± 6.8 mm measured by preoperative computed tomography/magnetic resonance. All of the patients underwent triple imaging using all modalities.

Aortic Stent-Graft Implantation
The technique of stent-graft implantation has been described in detail elsewhere.1,2 The stent grafts were customized according to the
individual patient’s anatomy with respect to length and diameter as taken from preinterventional 3D tomographic reconstruction (Talent, Medtronic). The average length of the stent grafts was 132±20 cm. The implantation was performed under general anesthesia with surgical cutdown to the femoral artery, whereas the brachial insertion for the pigtail catheter was performed percutaneously. The stent-graft implantation was accompanied by triple imaging including intraprocedural ANGIO, TEE, and IVUS.

**IVUS**
IVUS has proven imaging capability not only in coronary arteries, but also in big vessels, such as the aorta. IVUS enables exact localization of the entry location between the false and true lumen with respect to length and diameter as taken from preinterventional 3D tomographic reconstruction (Talent, Medtronic). The average length of the stent grafts was 132±20 cm. The implantation was performed under general anesthesia with surgical cutdown to the femoral artery, whereas the brachial insertion for the pigtail catheter was performed percutaneously. The stent-graft implantation was accompanied by triple imaging including intraprocedural ANGIO, TEE, and IVUS.

**ANGIO**
The procedure was performed in the catheterization laboratory under sterile conditions using a HICOR digital fluoroscopy system also allowing for digital subtraction images (Siemens). Angulation of the X-ray tube reached 45° in every direction (right anterior oblique, left anterior oblique, cranial, and caudal), allowing orthogonal views. Repeat contrast injections were performed during the endovascular intervention via the pigtail catheter placed in the upper thoracic aorta via the left subclavian artery. For better visualization and accurate measurements, a radiopaque ruler was placed under the patient parallel to the aorta. Iopamidol (Solutrast 370, Bracco-Byk Gulden) was used as contrast agent.

**TEE**
The contribution of TEE for the diagnosis of aortic dissection and aneurysm is well established. For interventional guidance, a multiplane transesophageal probe connected to a Sonos 5500 ultrasound system (both Philips Medical System) was used (Omniplane II). The ultrasound frequency was 6.25 MHz. TEE was analyzed online, independent of angiographic results and findings. After independent determination and notification of any specific finding, the results by each imaging method were matched. TEE was recorded on a S-VHS recorder (Panasonic), as well as digitally for online and offline analysis.

**Statistics**
Descriptive statistics are given as mean ± SD. Continuous and categorical variables were compared using either the Student t test or McNemar test when appropriate. For comparison of TEE, ANGIO, and IVUS, the ANOVA approach was chosen. Statistical significance was considered at a P<0.05 each. The analysis was performed using SPSS for Windows version 10.07.

**Results**
The results of the comparison among ANGIO, TEE, and IVUS in guiding stent-graft implantation in aortic type-B dissection are listed in the Table. Whereas the proximal entry was localized in all of the methods, the number of all entries detected by IVUS and TEE was higher than with ANGIO alone (52 and 43 versus 34; P<0.005 each). IVUS and TEE were also superior in the diagnosis of false and true lumen (42 and 39 versus 32; P<0.05 each) (Figures 1 and 2), the assessment of slow flow in the false lumen post stent-graft implantation (32 and 31 versus 24; P<0.05 each), and incomplete stent-graft apposition (18 and 16 versus 9;
IVUS alone was the best method for side-branch evaluation or interrogation (42 versus 33 and 27; \(P < 0.05\) and \(P < 0.005\); Figure 1), whereas TEE was superior to both IVUS and ANGIO in the detection of endoleaks (5 versus 0 and 1; \(P < 0.05\)). In 6 of 42 patients, 2 stent grafts were implanted. Angiographic imaging, TEE, and IVUS were executed without any complications. The additional time required for the use of IVUS imaging ranged between 4 and 6 minutes; no extra time was needed for TEE and catheter ANGIO.

**Discussion**

ANGIO, TEE, and IVUS have demonstrated a specific capability to diagnose aortic type-B dissection and to safely guide stent-graft implantation (Figures 1 through 3).\(^1\,^2\,^4\,^13\,^15\) ANGIO is the method of first choice for the guidance of aortic stent-graft placement in aortic type-B dissection because of its ability to give the operator an immediate aortic overview, which is necessary for safe guidance (Figure 3). The exact anatomy of the aorta, including the site of the entry, is often difficult to identify on contrast ANGIO, especially when the entry is located close to the left carotid and/or subclavian artery. Because of the multiple plane access to the aorta, both IVUS and TEE offer valuable and incremental information for the implantation procedure. In a direct comparison of 48 stent-graft implantations in 42 patients, we could show that ultrasound techniques provide additional information superior to that of ANGIO, such as true and false lumen identification, detection of slow flow in the false lumen after stent-graft implantation, and the documentation of endoleaks or incomplete stent-graft apposition.\(^4\,^5\,^7\,^8\) With color Doppler echocardiography, TEE was superior to ANGIO and especially to IVUS in the detection of endoleaks after stent-graft implantation, a finding confirmed by others.\(^13\,^15\) Rapezzi et al\(^14\) assessed 7 perigraft leaks in 22 patients with TEE in comparison with only 2 with ANGIO (\(P = 0.02\)). Rocchi et al\(^15\) recently reported on 13 proximal “peri-stent leaks” detected by TEE in comparison with only 6 by ANGIO in a group of 42 patients (\(P = 0.008\)). The goal of stent-graft placement in aortic type-B dissection is to seal proximal entries to the false lumen, reestablish the collapsed true lumen, and resolve situations of malperfusion syndrome or ischemia.\(^1\,^2\,^16\) ANGIO, TEE, and IVUS were able to detect the main entry of the dissection, which is essential for stent-graft procedures (Figures 1 through 3). In this context, however, IVUS and TEE were able to detect significantly

**Figure 1.** A 68-year-old male with recurrent pain after 4 months of conservative treatment after diagnosis of type-B aortic dissection. Left: IVUS can easily identify sidebranches the offgoing arteries (left renal artery, arrow) from the true or false lumen. TL indicates true lumen; FL, false lumen. The IVUS catheter is located in the true lumen. Right: arrow indicates the entry of a dissected descending thoracic aorta.

**Figure 2.** A 53-year-old male, 5 weeks after acute thoracic pain and diagnosis of aortic type-B dissection. Left: long axis view of the entry site of a type-B aortic dissection in 2D and color Doppler TEE before stent-graft implantation. Arrow marks the entry. TL indicates true lumen; FL, false lumen. Right: post-stent-graft implantation. Arrow indicates the bright echo of the stent graft; white line points to the beginning formation of clot in the false lumen.
more secondary entries\textsuperscript{15,17} than ANGIO (52 and 43 versus 34; \( P<0.005 \) each); thus, ultrasound results led to an extension of aortic segments to be covered by implanting a second stent-graft in 6 patients, a finding often undetected by ANGIO alone.\textsuperscript{13} ANGIO alone also has difficulties in the localization of the guide wire in either the true or false lumen (Table). In 4 of 44 stent-graft implantations in our group, the guide wire had to be repositioned based on IVUS or TEE after satisfactory positioning in ANGIO. This finding is confirmed by Rocchi et al.,\textsuperscript{15} where in 3 of 28 patients, guide wire repositioning was necessary after TEE. Because of the multiple plane access, TEE and IVUS provide incremental information compared with ANGIO in the measurement of aortic dimensions in all of the cases of aortic pathology.\textsuperscript{4,9,11,18} With triple imaging modalities (ANGIO, TEE, and IVUS) planned for all of the procedures, the additional time required for IVUS was \( \leq 6 \) minutes, considering that ANGIO and TEE are compulsory. However, IVUS and TEE afford 1 additional trained person in the room participating in the procedure.

**Limitations**

Because of eccentric catheter position, in some patients, parts of the arterial wall could not be visualized completely with IVUS, which may lead to overestimation of aortic diameters. Controllable IVUS catheters at the tip could overcome this technical limitation but are not yet commercially available.

With no recommendations at present for the technical performance of stent-graft placement, ANGIO, TEE, and IVUS are used at the discretion of the interventionalist. Another important consideration is the echogenic characteristics of the fabric of a given stent graft; whereas Dacron, used in this study, allows visualization beyond the fabric, other commercial fabric, such as polytetrafluoroethylene, has physical properties that limit ultrasound visualization because of absorption and reflection. With Doppler interrogation, however, stent apposition and relevant endoleaks (type I and II) will be detected by TEE, regardless of the material. The only major disadvantage of TEE is the limited access to the segment of the descending thoracic aorta, behind the right bronchus, parts of the arch and abdominal segments beyond the celiac trunk. IVUS cannot be performed simultaneously with stent-graft placement, except if used with a second wire in the aorta, whereas TEE is uniquely suited for parallel imaging and intraprocedural monitoring.

**Conclusions**

Guidance of aortic stent-graft implantation in type-B aortic dissection is improved by complimentary use of contrast fluoroscopy, multiplane TEE with Doppler flow interrogation, and IVUS. This imaging approach implies no additional risk and provides online visualization. Nevertheless, preinterventional and postinterventional computed tomography/magnetic resonance, as well as perinterventional ANGIO, will not be replaced. However, procedural complications with stent-graft implantation are likely to be avoided, because TEE and IVUS help navigate guide wires and catheters in the true lumen, which improves safety of stent-grafting and, thus, may eventually improve procedural outcomes, especially in the treatment of aortic dissection.

**References**


How to Guide Stent-Graft Implantation in Type B Aortic Dissection?: Comparison of Angiography, Transesophageal Echocardiography, and Intravascular Ultrasound

Dietmar H. Koschyk, Christoph A. Nienaber, Malgorzata Knap, Thomas Hofmann, Yskert V. Kodolitsch, Valeria Skriabina, Mohammed Ismail, Olaf Franzen, Tim C. Rehders, Christoph Dieckmann, Gunnar Lund, Hermann Reichenspurner and Thomas Meinertz

Circulation. 2005;112:I-260-I-264
doi: 10.1161/CIRCULATIONAHA.104.525972

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2005 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/112/9_suppl/I-260

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/