Influence of the revised nellix instructions for use on outcomes after endovascular aneurysm sealing

Sebastian Zerwes, Hans-Kees Bruijnen, Yvonne Gosslau, Rudolf Jakob, Alexander Hyhlik-Dürr

Angaben zur Veröffentlichung / Publication details:

Zerwes, Sebastian, Hans-Kees Bruijnen, Yvonne Gosslau, Rudolf Jakob, and Alexander Hyhlik-Dürr. 2018. "Influence of the revised nellix instructions for use on outcomes after endovascular aneurysm sealing." *Journal of Endovascular Therapy* 25 (4): 418–25. https://doi.org/10.1177/1526602818781353.

Influence of the Revised Nellix Instructions for Use on Outcomes After Endovascular Aneurysm Sealing

Sebastian Zerwes, MD[1], Hans-Kees Bruijnen, MD[1], Yvonne Gosslau, MD[1], Rudolf Jakob, MD[1], and Alexander Hyhlik-Dürr, MD, PhD[1]

Abstract

Purpose: To evaluate the impact of the revised Nellix instructions for use (IFU) from 2016 on clinical outcomes and anatomic applicability by retrospectively applying them to a cohort treated with endovascular aneurysm sealing according to the original IFU 2013. **Methods:** A single-center study was conducted of 100 consecutive patients (mean age 72±8 years, range 46–91; 89 men) treated electively with standard bilateral EVAS from July 2013 to August 2015 and followed through December 2017. Procedures previously classified within and outside the original IFU from 2013 (75 and 25, respectively) were reclassified according to the revised IFU 2016 (34 and 66, respectively). Stepwise backward logistic regression analysis was performed to evaluate the prognostic value of specific anatomic features for the development of endoleak and/or migration. **Results:** The single most important morphologic feature disqualifying patients from being within IFU 2016 was a thrombus ratio >1.4 (36 of 41 reclassified patients). Overall technical success was 98% (100% within vs 97% outside IFU 2016, p=0.323) and 30-day mortality was 3% (0% within vs 5% outside IFU 2016, p=0.251). During a median follow-up of 31 months (range 0–53), overall mortality was 21% (15% within vs 24% outside IFU 2016, p=0.469); aneurysm-related mortality was 8% (3% within vs 11% outside IFU 2016, p=0.533). Twenty-six patients developed an endoleak (6 within vs 20 outside IFU 2016, p=0.172) and 23 had migration (4 within vs 19 outside IFU 2016, p=0.088). Both proximal neck length <10 mm and neck angulation >60° were positive predictors for the development of endoleak and/or migration. A reintervention was performed in 26 patients (7 within vs 19 outside IFU 2016, p=0.376). While a significant difference was found between the within vs outside IFU 2016 groups with regard to freedom from migration (p=0.026) and the composite freedom from endoleak and/or migration (p=0.021), there were no significant differences in survival (p=0.201) or freedom from reintervention (p=0.505), suggesting a limited effectiveness of the new IFU 2016. **Conclusion:** The IFU 2016 reduced the anatomic applicability to 34% from 75% for the original IFU 2013. The lack of significant intergroup differences in terms of survival and reinterventions suggests a limited effectiveness of the new IFU 2016.

Keywords

abdominal aortic aneurysm, anatomic applicability, complications, endoleak, endovascular aneurysm sealing, instructions for use, migration, mortality, reintervention

Introduction

In 2011, a new concept was introduced to vascular surgery: endovascular aneurysm sealing (EVAS).[1,2] The new system was different from all previous aortic stent-grafts because it abandoned the, until then, untouched principles of proximal and distal fixation associated with endovascular aneurysm repair (EVAR). Instead, polymer-filled endobags fixed the EVAS stent-grafts within the aorta and excluded the aneurysm by completely filling the sac with polymer.[1–4]

While this new device obviously came with instructions for use (IFU),[5] the idea of "sealing the entire aneurysm" was such a promising and seductive concept that it seemed to lure vascular surgeons to go beyond the IFU.[6,7] This was most evident in the EVAS FORWARD Global Registry, in which 37% of patients were treated outside the IFU.[8] More interestingly

[1]Department of Vascular and Endovascular Surgery, Klinikum Augsburg, Germany

Corresponding Author:
Sebastian Zerwes, Department of Vascular and Endovascular Surgery, Klinikum Augsburg, Stenglinstraße 2, 86156 Augsburg, Germany.
Email: sebastian.zerwes@klinikum-augsburg.de

Table 1. Original vs Revised Instructions for Use.

Anatomic Features	Original IFU 2013	Revised IFU 2016
Iliac and femoral arteries	Access that allows atraumatic device introduction	Same
Proximal aortic neck diameter, mm	18–32	18–28
Minimum proximal aortic neck length, mm	⩾10	Same
Proximal aortic neck angulation, deg	⩽60	Same
Aortic aneurysm blood lumen diameter, mm	⩽60	⩽70
Ratio of maximum aortic aneurysm diameter to maximum aortic blood lumen diameter	Not required	⩽1.4
Distal iliac artery, mm	Diameter 8–35	Seal zone length ⩾10 and diameter 9–25

Abbreviation: IFU, instructions for use.

though, toward the end of 2016, the IFU for EVAS were refined due to higher than anticipated rates of implant displacement, endoleaks, and/or aneurysm enlargement.[9]

This event sparked 2 important questions: First, how do the new IFU impact the anatomic applicability of the device, and second, what is the effect of the new IFU on the outcomes following EVAS procedures? To answer these questions, an analysis was conducted to retrospectively apply the updated IFU 2016 to 100 EVAS cases that were carried out at our institution. The goal was to evaluate the influence of the revised IFU on outcomes as well as anatomic applicability.

Methods

Study Design

This single-center retrospective study involved 100 consecutive patients (mean age 72±8 years, range 46–91; 89 men) treated electively with standard bilateral EVAS implantation from July 2013 to August 2015 and followed through December 2017. Symptomatic patients were included but not those with ruptured aneurysms. All nonstandard cases involving chimney, uni-iliac, or repair procedures were excluded. The Ethics Committee of the Klinikum Augsburg waived the need for ethics approval and the need to obtain consent for the collection, analysis, and publication of the retrospectively obtained and anonymized data used in this study.

Patients previously classified within and outside the original IFU from 2013 (75 and 25, respectively) were reclassified according to the revised IFU (34 and 66, respectively) in accordance with the anatomic conditions described in the updated IFU published by Endologix in September 2016 (Table 1).[9] Patient demographics and comorbidities according to the IFU 2016 status are shown in Table 2.

EVAS Procedure

Preoperatively, all patients had computed tomography (CT) of the abdominal aorta (0.75-mm collimation, 1-mm reconstruction layer thickness). All images were processed on a vascular workstation to determine the length of the stent-grafts and estimate the polymer volume using 3-dimensional sizing software (EndoSize; Therenva SAS, Rennes, France). The procedures were performed in a hybrid operating room equipped with an Artis Zeego unit (Siemens AG, Munich, Germany) and were carried out under general anesthesia. All patients had the first postoperative CT scan before discharge. Follow-up surveillance was performed using contrast-enhanced ultrasound at 3 and 6 months and CT at 12 months and annually thereafter.

Outcome Measures

Events of primary and secondary interest were defined according to the guidelines for EVAR procedures from the Society for Vascular Surgery.[10] Procedures were rated as technically successful when the stent-graft placement resulted in complete sealing without type I or III endoleak or conversion to open surgery. In this analysis, the events of primary interest were technical success along with early and late mortality. Secondary outcomes were all procedure- or device-related complications (endoleak, endograft migration, endograft limb occlusion, etc). Migration was defined as any stent-graft movement ⩾4 mm related to a predefined reference vessel or any migration leading to an endoleak.[11]

Statistical Analysis

Continuous data are presented as the means ± standard deviation or median [interquartile range: Q1, Q3]; categorical data are given as the counts (percentage). Nominal variables were evaluated using the Fisher exact test, while numeric variables were compared with the Mann-Whitney *U* test because most were not normally distributed. The Kaplan-Meier method was used to estimate survival, freedom from endoleak and/or migration, and freedom from reintervention. The curves were compared using the log-rank test. A

Table 2. Patient Demographics and Comorbidities.[a]

	Overall (n=100)	IFU 2016 (n=34)	Outside IFU 2016 (n=66)	p
Age, y	73 (46–91)	73 (46–85)	73 (53–91)	
Men	89	32 (94)	57 (86)	
BMI >30 kg/m^2	37	17 (50)	20 (30)	0.049
Hypertension	89	31 (94)	58 (88)	0.489
CAD	43	11 (33)	32 (49)	0.198
CABG	9	2 (6)	7 (11)	0.714
Arrhythmia	17	9 (27)	8 (12)	0.088
COPD	21	8 (24)	13 (20)	0.611
Renal insufficiency[b]	8	2 (6)	6 (9)	0.715
Diabetes	18	9 (28)	9 (14)	0.107
Hyperlipidemia	61	24 (73)	37 (56)	0.128
Smoking	60	17 (50)	43 (66)	0.191
MI	20	5 (15)	15 (23)	0.437
Abdominal surgery / trauma	15	3 (9)	12 (18)	0.373
PVD	17	6 (18)	11 (17)	>0.999
ASA				0.795
I	1	0	1 (2)	
II	32	10 (30)	22 (33)	
III	60	22 (67)	38 (58)	
IV	6	1 (3)	5 (8)	

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CABG, coronary artery bypass graft; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; IFU, instructions for use; MI, myocardial infarction; PVD, peripheral vascular disease.
[a]Continuous data are presented as the median (range); categorical data are given as the counts (percentage).
[b]Creatinine >2.0 mg/dL.

stepwise backward logistic regression analysis was performed to evaluate the prognostic value of specific anatomic features [thrombus ratio >1.4, proximal neck diameter >28 mm, proximal neck length <10 mm, proximal neck angulation >60°, common iliac artery (CIA) diameter >35 mm, and a distal sealing zone <10 mm] for the development of an endoleak and/or migration. Outcomes are presented as the odds ratio (OR) and 95% confidence interval (CI). The threshold of statistical significance was $p<0.05$. Statistical analyses were performed using StatsDirect (version 3.1.8; StatsDirect Ltd, Altrincham, UK).

Results

IFU Status Reclassification

Categorization according to the revised IFU 2016 resulted in 41 IFU 2013–compliant patients being classified as outside the revised IFU 2016. These patients had at least one of the following anatomic features: 36 (88%) had a ratio of maximum aortic aneurysm diameter to maximum aortic blood lumen diameter >1.4, 7 (17%) had an aortic neck diameter >28 mm, 1 (2%) had a diameter <9 mm in at least 1 CIA, and 1 (2%) had a diameter >35 mm in at least 1 CIA. In 6 (15%) the distal seal zone had a length <10 mm. A summary of aneurysm morphology is presented in Table 3.

Early Outcomes

Technical success was achieved in 98% (100% within vs 97% outside the IFU 2016). The 2 failed cases were due to aneurysm rupture in one and a CIA rupture in the other. The former patient was successfully treated endovascularly with a Nellix-in-Nellix application, while the CIA rupture patient was converted to open surgery. Both patients died within 30 days: the converted patient 8 days after surgery and the Nellix-in-Nellix patient from intracranial bleeding at day 27. A third patient died from multiple organ dysfunction syndrome and sepsis 23 days after surgery. All 3 patients dying within 30 days were outside the IFU 2016.

Late Outcomes

Over a median follow-up of 31 months (range 0–53), the overall mortality (Table 4) was 21% (15% within vs 24% outside the IFU 2016; p=0.469). Of the 34 patients treated within the IFU 2016, 5 died: 1 aneurysm-related, 3 due to nonaneurysm-related events, and 1 due to unknown causes, while 16 of the 66 patients treated outside the IFU 2016 expired: 7 aneurysm-related, 7 nonaneurysm-related, and 2 unknown. The Kaplan-Meier curve for cumulative survival is displayed in Figure 1A. At 3 years, the survival estimates

Table 3. Aneurysm Characteristics According to the Instructions for Use Status.[a]

Characteristics	IFU 2016 (n=34)	Outside IFU 2016 (n=66)	p
Maximum AAA diameter, mm	54 [51, 58] (45–72)	55 [52, 63] (44–93)	0.378
Maximum aortic blood lumen diameter, mm	47 [41, 54] (37–60)	37 [34, 43] (25–81)	<0.001
Aortic neck diameter, mm	23 [22, 25] (20–28)	23 [22, 27] (18–35)	0.376
Aortic neck length, mm	26 [19, 33] (10–50)	26.5 [20, 35] (0–60)	0.798
Aortic neck angulation, deg	15 [0, 30] (0–53)	21.5 [0, 49] (0–102)	0.114
Left common iliac artery diameter, mm	16 [14, 20] (11–33)	16 [14, 21] (9–51)	0.477
Right common iliac artery diameter, mm	17 [14, 20] (10–33)	17 [14, 22] (8–48)	0.555

Abbreviations: AAA, abdominal aortic aneurysm, IFU, instructions for use.
[a]Data are presented as the median [interquartile range Q1, Q3] (absolute range).

Table 4. Clinical Outcomes and Reinterventions According to the Instructions for Use Status.[a]

	Total (n=100)	IFU 2016 (n=34)	Outside IFU 2016 (n=66)	p
Technical success, %	98	34 (100)	64 (97)	0.323
Mortality, 30 days, %	3	0 (0)	3 (5)	0.251
Mortality, all cause, %	21	5 (15)	16 (24)	0.469
Aneurysm-related	8	1 (3)	7 (11)	0.533
Rupture during EVAS	2	0 (0)	2 (3)	0.422
Rupture post EVAS	2	1 (3)	1 (2)	0.701
Endoleak	26	6 (18)	20 (30)	0.172
Type Ia	21	4 (12)	17 (26)	0.088
Type Ib	4	1 (3)	3 (5)	0.197
Type II	2	0 (0)	2 (3)	0.323
Type V	3	2 (6)	1 (3)	0.079
Device migration	23	4 (12)	19 (29)	0.088
Endoleak and/or migration	34	6 (18)	28 (42)	0.013
Partial endograft limb thrombosis	4	2 (6)	2 (3)	0.214
Acute limb ischemia	4	2 (6)	2 (3)	0.390
Access-site hematoma	1	1 (3)	0 (0)	0.572
Total patients with complications	40	10 (29)	30 (45)	0.239
Reinterventions	26	7 (21)	19 (29)	0.376
Conversion/explantation	17	5 (15)	12 (18)	0.661
Nellix-in-Nellix application	8	0 (0)	8 (12)	0.034
Access-site revision	1	1 (3)	0 (0)	0.161
Transfemoral embolectomy	4	2 (6)	1 (2)	0.491

Abbreviations: CIA, common iliac artery; EVAS, endovascular aneurysm sealing; IFU, instructions for use.
[a]Data are given as the counts (percentage).

were 84% (95% CI 71% to 97%) for patients within the IFU vs 76% (95% CI 66% to 87%) for patients outside the IFU (p=0.209).

Endoleaks and Device Migration. In total, 26 patients were affected by an endoleak (18% within vs 30% outside IFU 2016, p=0.172). The endoleaks in the group treated within the IFU consisted of 4 type Ia endoleaks (1 in combination with a type Ib) and 2 type V endoleaks that were considered a result of endotension with growth of the aneurysm. The endoleaks in the group treated outside the IFU consisted of 17 type Ia (2 in combination with a type II and another in combination with a type Ib), 2 isolated type Ib, and 1 type V. Of all observed endoleaks, only 2 were detected within 30 days, while 24 were late endoleaks (median time postimplant 29.6 months, range 2.6–52.5).

Overall, 23 patients presented with migration (12% within vs 29% outside IFU 2016, p=0.088). Fifteen (65%) occurred in combination with an endoleak. Hence, endoleak and/or migration occurred in 34 cases (18% within vs 42% outside IFU 2016, p=0.013). The Kaplan-Meier curve for the cumulative freedom from endoleak and/or migration is displayed in Figure 1B. At 3 years, the estimates were 81% (95% CI 68% to 95%) for patients within the IFU vs 50% (95% CI 37% to 63%) for patients outside the IFU

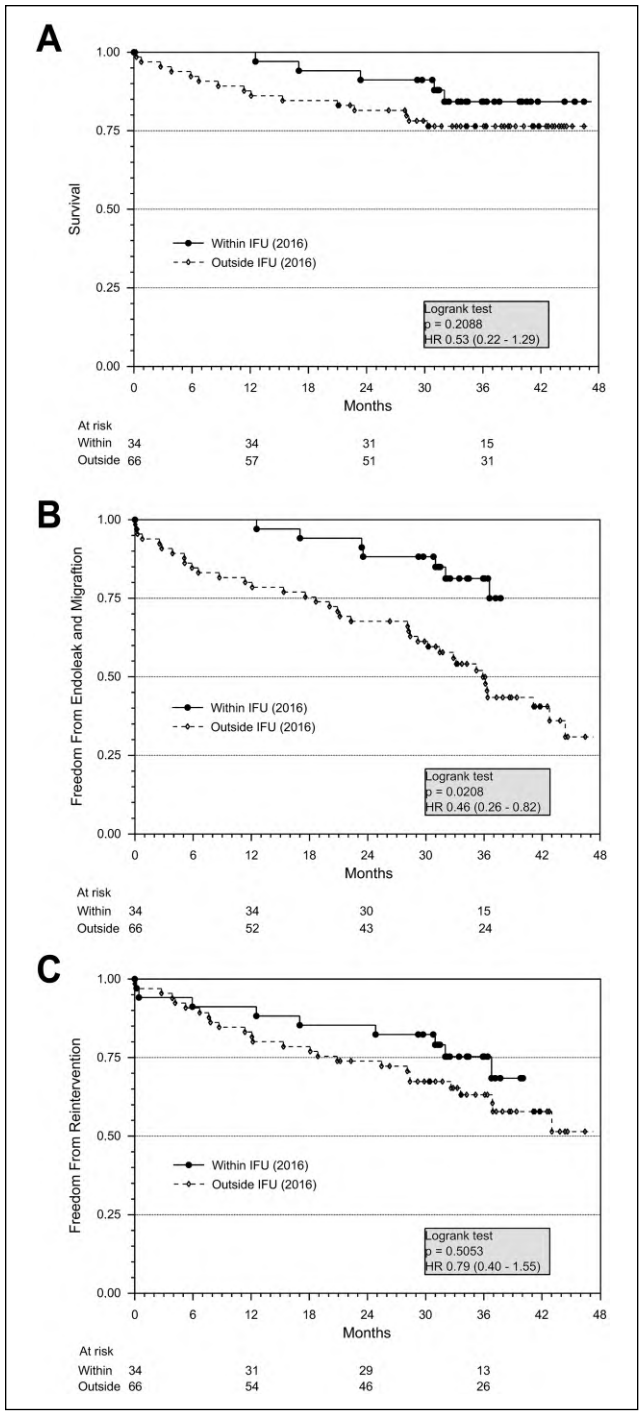

Figure 1. Kaplan-Meier curves for (A) cumulative survival, (B) freedom from endoleak and migration, and (C) freedom from reintervention. The standard error did not exceed 10% at 36 months. HR, hazard ratio; IFU, instructions for use.

(p=0.021). Figure 2 shows the temporal distribution of the 34 endoleak/migration events (median 29.3 months, range 0–52.5).

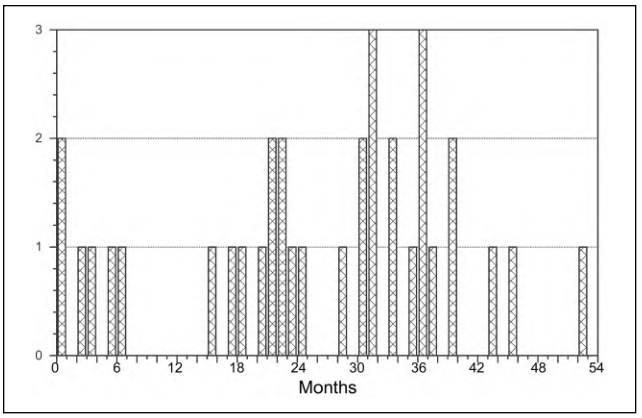

Figure 2. Distribution of 34 endoleak and/or migration events over time.

Complications

Five patients (9% within vs 3% outside the IFU 2016, p=0.334) were affected by thromboembolic events. Four of these patients suffered partial endograft limb thromboses, 3 of whom also sustained lower limb thromboembolic events resulting in acute limb ischemia (Rutherford IIb[12]). Another patient also presented with acute limb ischemia but without signs of endograft limb thrombosis. All symptomatic patients but one were treated with transfemoral embolectomy. Detailed descriptions of those cases has been published.[13] The symptomatic patient who was not treated with embolectomy underwent Nellix explantation because the ischemia occurred in the setting of migration and aneurysm growth. One patient suffered from bilateral inguinal hematomas that required surgical treatment. An overview of clinical outcomes can be found in Table 4.

Reinterventions

A secondary intervention was performed in 26 patients: 7 (21%) patients within and 19 (29%) patients outside the IFU 2016 (p=0.376). In the patients within the IFU 2016 there were 5 conversions to open surgery and 2 transfemoral embolectomies; one of these patients had the surgically treated hematomas. In the 19 patients outside the IFU 2016, the secondary interventions were 12 (18%) conversions to open surgery, 8 (12%) Nellix-in-Nellix extensions (2 of which were later converted to open surgery), and 1 (2%) transfemoral embolectomy. An overview of all secondary interventions can be found in Table 4, while Figure 1C displays the Kaplan-Meier curve for cumulative freedom from reintervention. At 3 years, the survival estimates were 75% (95% CI 60% to 90%) for patients within the IFU vs 63% (95% CI 51% to 75%) for patients outside the IFU (p=0.505).

Table 5. Risk Factors for the Endoleak and/or Migration Composite Event.

Variable	Odds Ratio (95% CI)	p
Univariate analysis		
Thrombus ratio >1.4	2.29 (0.90 to 5.83)	0.083
Neck diameter >28 mm	0.76 (0.16 to 3.63)	0.727
Neck length <10 mm	5.61 (1.13 to 27.84)	0.035
Neck angulation >60 deg	6.02 (1.29 to 28.08)	0.022
Right CIA >35 mm	0.75 (0.04 to 14.57)	0.852
Left CIA >35 mm	0.95 (0.06 to 16.05)	0.973
Distal sealing zone <10 mm	0.50 (0.08 to 3.05)	0.453
Multivariate analysis		
Neck length <10 mm	4.35 (0.96 to 19.68)	0.056
Neck angulation >60 deg	5.22 (1.20 to 22.62)	0.027

Abbreviations: CI, confidence interval; CIA, common iliac artery.

Table 6. Observed Event vs Estimated Frequency Based on the Logistic Regression Analysis for Endoleak and/or Migration.

N	Neck Length <10 mm	Neck Angulation >60 deg	Observed Event	Estimated Frequency
83	No	No	0.277	0.277
9	No	Yes	0.667	0.667
8	Yes	No	0.625	0.625

Risk Factor Analysis

The anatomic features with the highest likelihood of being predictive of endoleak and/or migration (Table 5) were neck length <10 mm (p=0.056) and neck angulation >60° (p=0.027). Table 6 shows the observed events of endoleak and/or migration vs the estimated frequency according to the logistic regression model.

Discussion

Using the updated IFU from 2016 reduced the anatomic applicability of the Nellix device significantly. While previously 75% of the patients in this cohort had met the original IFU 2013, only 34% did so according to the new IFU from 2016. While there were multiple morphologic factors disqualifying patients from being within IFU 2016, the single most important anatomic feature was a thrombus ratio >1.4, present in 88% of the patients that switched from within the IFU 2013 to outside the IFU 2016. These findings mirror the recently presented data by Carpenter et al.[14] It is worth noting that this particular aspect of the revised IFU restricts the use of the device to aneurysms with a small thrombus burden, a morphologic feature that is commonly not addressed in the IFU of conventional EVAR devices.[15,16]

Of concern were the 2 cases in which the endobags caused a rupture of the aneurysm and a CIA, respectively. In the first, the pressure transducer stopped working during the secondary fill, and it is likely that the rupture happened during that uncontrolled injection of polymer. Aneurysm ruptures triggered by the endobags have been reported,[17,18] so it is important to be particularly cautious once the precalculated volume has been exceeded and/or a secondary fill pressure is >200 mm Hg.[7,13]

The second endobag-triggered rupture affected an extremely calcified CIA and resulted in open conversion. One potential explanation might be the fact that after balloon dilation of the Nellix stent-grafts there was only little space left between the stent-graft and the CIA wall. Hence, the filling of the endobags exerted an extremely high pressure within the calcified lesion, eventually causing it to rupture. Another explanation might be a plaque dislocated during the initial introduction of the Nellix stent-graft through the calcified lesion, later perforating and rupturing the CIA by the force of the endobag. Accordingly, great caution must be exercised in cases with tight iliac arteries.

In terms of mortality, both patients with failed procedures died within 30 days; however, it is important to note that these cases happened during the early learning phase with the device. Although the 21% all-cause mortality over a median 31-month follow-up was greater than in previously reported EVAS studies at mean follow-up intervals of 12 to 24 months,[8,14,18–20] there was no significant difference in mortality between the within (15%) vs outside (24%) IFU 2016 groups. This observation is in line with the comparative data recently published by Zoethout et al.[20] One potential explanation of the rather high all-cause mortality in the present study might be the fact that two-thirds of the

patients were ranked American Society of Anesthesiologists class III or IV, representing a severely diseased patient cohort.

Although there was a significant difference between the patients treated inside and outside the IFU 2016 as regards the endoleak and/or migration outcome, suggesting a positive effect of the updated IFU 2016, the rate of both endoleaks and migrations within the IFU group is still alarming and certainly higher than in previously published data.[7,14,17,18,20] Another noteworthy observation is the time period during which the aforementioned complications occurred. The median interval to the "endoleak and/or migration" event was 29.3 months (range 0–52.5). A closer look at Figure 2 reveals that 6 (18%) of the 34 events occurred within the first year postimplant, while another 9 (26%) were detected during the second year. Hence, more than half (56%) of the endoleaks and migrations were detected >2 years into follow-up. This has 2 profound consequences. First, it might explain the deviation from previously published data that reported lower endoleak and migration rates post EVAS.[7,14,17,18,20] Second, the present study had a median follow-up of just over 2.5 years, indicating that the rate of endoleaks and migrations is likely to grow in the long term. This warrants a rigorous long-term surveillance regime for any patient who underwent an EVAS procedure, regardless of compliance with the IFU 2016.

Regression analysis revealed 2 proximal neck characteristics (length <10 mm and angulation >60°) to be significant contributors to the development of endoleak and/or migration. Both factors are well known predictors of adverse outcomes, as they represent hostile anatomy and as such should be avoided in EVAS implantations.[21] Interestingly, thrombus load was not a positive predictor for the development of endoleak and migration.

Among the 7 patients compliant with the IFU 2016 who underwent a secondary intervention (6 for endoleak or migration), all had surgery; not a single endovascular repair was done. However, 8 of the 21 reinterventions in the 19 patients outside the IFU 2016 were a Nellix-in-Nellix application. Notably, while 28 (42%) of the 66 patients treated outside the IFU 2016 presented with endoleak and/or migration, only 19 received a secondary intervention, leaving about one-third of the patients untreated. This was due to multiple reasons but included patients who were either too sick for a secondary intervention, refused a reintervention, or had not yet undergone another procedure at the point of data analysis.

There is debate going on over how to treat endoleaks and migrations after EVAS. Endovascular options, such as coil or liquid embolization,[22,23] have been described in addition to the Nellix-in-Nellix application that Donselaar et al[24] evaluated. Open repair also represents a possible treatment modality.[25] These options have one thing in common: long-term data regarding durability of each method are lacking. In our department endoleaks and migrations have been treated both endovascularly and with open surgery. However, the Nellix-in-Nellix application was especially used during the early experience with the device, when the underlying mechanism that led to the endoleak and/or migration was not yet very well understood. In cases of severe endoleaks and/or migrations, the tendency now is toward open surgical repair whenever the patient can tolerate it. However, regardless of the modality of the reintervention, it must once again be stressed that there was no significant difference in frequency of reinterventions between the patients treated within and outside the IFU 2016. These findings question the effectiveness of the revised IFU in terms of lowering secondary interventions and improving survival and are not in line with the data presented by Carpenter et al.[14]

Limitations

This was a single-center experience that included a learning curve with a new device. In addition, both according to the IFU 2013 and the updated IFU 2016, the numbers of procedures performed outside the IFU were high. Furthermore, the long-term behavior of the polymer, both on macroscopic and microscopic levels, remains unknown. As such, the data still represent a snapshot in time and must be interpreted as preliminary results, which are likely to change in the long term.

Conclusion

Applying the IFU 2016 resulted in a 34% rate of cases compliant with the IFU (vs 75% for the IFU 2013), representing a significant decrease in anatomic applicability. The single most important morphologic feature disqualifying patients from compliance with the IFU 2016 was a thrombus ratio >1.4. While a significant difference was found between the groups within vs outside the IFU 2016 with regard to freedom from endoleak and/or migration, there were no significant differences for the survival and reintervention outcomes, suggesting a limited effectiveness of the new IFU 2016. Both a proximal neck <10 mm and proximal neck angulation >60° were reliable predictors of endoleak and/or migration. Further studies with longer follow-up are needed.

Authors' Note

An earlier version of these data was presented at the Charing Cross Symposium (April 26, 2017; London, UK).

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Sebastian Zerwes and Rudolf Jakob were formerly paid consultants for Endologix.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Sebastian Zerwes https://orcid.org/0000-0001-5475-6696

References

1. Donayre CE, Zarins CK, Krievins DK, et al. Initial clinical experience with a sac-anchoring endoprosthesis for aortic aneurysm repair. *J Vasc Surg*. 2011;53:574–582.
2. Krievins DK, Holden A, Savlovskis J, et al. EVAR using the Nellix sac-anchoring endoprosthesis: treatment of favourable and adverse anatomy. *Eur J Vasc Endovasc Surg*. 2011;42:38–46.
3. Ķīsis K, Krieviņš D, Naškoviča K, et al. Quality of life after endovascular abdominal aortic aneurysm repair: Nellix sac-anchoring endoprosthesis versus open surgery. *Medicina (Kaunas)*. 2012;48:286–291.
4. Karthikesalingam A, Cobb RJ, Khoury A, et al. The morphological applicability of a novel endovascular aneurysm sealing (EVAS) system (Nellix) in patients with abdominal aortic aneurysms. *Eur J Vasc Endovasc Surg*. 2013;46:440–445.
5. Endologix. Nellix EndoVascular Aneurysm Sealing System Instructions for Use. 2013.
6. Hoksbergen AW. Commentary: Endovascular aneurysm sealing for ruptured abdominal aortic aneurysms: does it work? *J Endovasc Ther*. 2015;22:810–812.
7. Zerwes S. Seduction and its impact on instructions for use. *J Endovasc Ther*. 2016;23:693–694.
8. Thompson MM, Heyligers JM, Hayes PD, et al; for the EVAS FORWARD Global Registry Investigators. Endovascular aneurysm sealing: early and midterm results from the EVAS FORWARD Global Registry. *J Endovasc Ther*. 2016;23:685–692.
9. Endologix. Important field safety notice: Updated instructions for use (IFU). 2016.
10. Chaikof EL, Blankensteijn JD, Harris PL, et al. Reporting standards for endovascular aortic aneurysm repair. *J Vasc Surg*. 2002;35:1048–1060.
11. England A, Torella F, Fisher RK, et al. Migration of the Nellix endoprosthesis. *J Vasc Surg*. 2016;64:306–312.
12. Rutherford RB. Clinical staging of acute limb ischemia as the basis for choice of revascularization method: when and how to intervene. *Semin Vasc Surg*. 2009;22:5–9.
13. Zerwes S, Nurzai Z, Leissner G, et al. Early experience with the new endovascular aneurysm sealing system Nellix: first clinical results after 50 implantations. *Vascular*. 2016;24:339–347.
14. Carpenter JP, Lane JS 3rd, Trani J, et al; Nellix Investigators. Refinement of anatomic indications for the Nellix System for endovascular aneurysm sealing based on 2-year outcomes from the EVAS FORWARD IDE trial [published online March 30, 2018]. *J Vasc Surg*. doi:10.1016/j.jvs.2018.01.031.
15. Stokmans RA, Teijink JA, Forbes TL, et al. Early results from the ENGAGE registry: real-world performance of the Endurant Stent Graft for endovascular AAA repair in 1262 patients. *Eur J Vasc Endovasc Surg*. 2012;44:369–375.
16. Verhoeven EL, Katsargyris A, Bachoo P, et al; GREAT European C3 Module Investigators. Real-world performance of the new C3 Gore Excluder stent-graft: 1-year results from the European C3 module of the Global Registry for Endovascular Aortic Treatment (GREAT). *Eur J Vasc Endovasc Surg*. 2014;48:131–137.
17. Reijnen MMPJ, Holden A. Status of endovascular aneurysm sealing after 5 years of commercial use. *J Endovasc Ther*. 2018;25:201–206.
18. Carpenter JP, Cuff R, Buckley 2C, et al,; Nellix Investigators. One-year pivotal trial outcomes of the Nellix system for endovascular aneurysm sealing. *J Vasc Surg*. 2017;65:330–336.e4.
19. Silingardi R, Coppi G, Ferrero E, et al. Midterm outcomes of the Nellix Endovascular Aneurysm Sealing System: a dual-center experience. *J Endovasc Ther*. 2016;23:695–700.
20. Zoethout AC, Boersen JT, Heyligers JMM, et al; DEVASS (Dutch Endovascular Aneurysm Sealing Study) Group. Two-year outcomes of the Nellix EndoVascular Aneurysm Sealing System for treatment of abdominal aortic aneurysms. *J Endovasc Ther*. 2018;25:270–281.
21. Stather PW, Wild JB, Sayers RD, et al. Endovascular aortic aneurysm repair in patients with hostile neck anatomy. *J Endovasc Ther*. 2013;20:623–637.
22. Ameli-Renani S, Morgan RA. Percutaneous interventions following endovascular aneurysm sac sealing: Endoleak embolization and limb-related adverse events. *Semin Vasc Surg*. 2016;29:135–141.
23. Ameli-Renani S, Morgan RA. Transcatheter embolisation of proximal type I endoleaks following endovascular aneurysm sealing (EVAS) using the Nellix device: technique and outcomes. *Cardiovasc Intervent Radiol*. 2015;38:1137–1142.
24. Donselaar EJ, Holden A, Zoethout AC, et al. Feasibility and technical aspects of proximal Nellix-in-Nellix extension for late caudal endograft migration. *J Endovasc Ther*. 2017;24:210–217.
25. Tolenaar JL, van den Ham LH, Reijnen MM, et al. Late conversion after sac anchoring endoprosthesis for secondary aortic aneurysm infection. *J Endovasc Ther*. 2015;22:813–818.