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State of Practice: Endovascular Treatment of Acute Aneurysmal SAH in Germany

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ABSTRACT

BACKGROUND AND PURPOSE: Acute aneurysmal SAH is a severe disease that requires prompt treatment. Endovascular coiling and neurosurgical clipping are established treatment options. Our intention was to determine the state of current practice in acute aneurysmal SAH treatment in Germany, with emphasis on logistic and temporal aspects.

MATERIALS AND METHODS: We interviewed 74 German university and nonuniversity hospitals with an anonymous questionnaire comprising 15 questions concerning the practice of treatment and diagnostics of acute aneurysmal SAH at their respective institutions. The response rate was 74% among all institutions (55/74); among university hospitals, 77%; and among nonuniversity hospitals, 72%.

RESULTS: The majority of all aneurysms were treated endovascularly (66% of acute aneurysmal SAH, 66% of unruptured aneurysms). Treatment on weekends was provided by 100% of endovascular and 96% of neurosurgical facilities. Average patients with acute aneurysmal SAH were not treated during the night (98%). Seventy percent of endovascular and 78% of neurosurgical treatments were not started later than 8:00 PM. Fifty-three percent of hospitals would not start a same-day diagnostic angiography in acute aneurysmal SAH if treatment was scheduled for the following day. Eighty-two percent of all centers performed DSA after clipping to evaluate the treatment results.

CONCLUSIONS: Our survey gives a detailed summary of the current practice of endovascular treatment and related topics in acute aneurysmal SAH in Germany and also reveals considerable changes in practice in comparison with older data.

ABBREVIATIONS: AASAH = acute aneurysmal SAH; ICH = intracranial hemorrhage

Acute aneurysmal SAH (AASAH) is a severe condition. The incidence worldwide is approximately 9 per 100,000 per year, but there are regional differences.[1] In Germany, the incidence is reported to be between 5.9 and 10–13 per 100,000.[1,2] While up to 12% of patients die before getting to the hospital,[3] therapeutic occlusion of the causative aneurysm is one of the most important treatment goals.[4,5] However, because SAH is a complex disease, many other factors also influence clinical outcome.[6] When the aneurysm is left untreated, the mortality rate is >60% within 1 year.[7] The major reason is the high risk of rebleeding after the initial rupture. This risk is time-dependent—up to 15% within the first hours and approximately 4% on the first day and then declining to 1%–2% per day for the first month.[8-10] Therefore, the timing of the obliterating therapy needs to be adapted to this course of the disease. The German Association of the Scientific Medical Societies recommends, in their SAH guidelines, obliterating aneurysm treatment within 72 hours.[9] The European Stroke Organization recommends the same 72-hour time window but states that the therapy should be performed as early as possible.[11] The American Heart Association and the American Stroke Association, in the latest update of their guidelines, postulate treatment as early as feasible without further specification.[12] According to the quality record by the largest German health insurance provider, Allgemeine Ortskrankenkasse (AOK), 7213 aneurysms were treated in 2008 in Germany.[13,14] To our knowledge, no published data are available that describe current clinical practice in Germany concerning the timing and availability of therapy in AASAH. Therefore, a nationwide cross-sectional survey was conducted.

MATERIALS AND METHODS

We compiled a questionnaire comprising 15 questions concerning the treatment of AASAH. All questionnaires were designed to

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From the Departments of Neuroradiology (H.J., J.L., H.B.) and Neurosurgery (N.T.) Ludwig-Maximilians-University Hospital, Munich, Germany; Department of Neuroradiology (H.J.), Paracelsus Medical University, Nuremberg, Germany; and Department of Neuroradiology (A.B.), Klinikum Augsburg, Augsburg, Germany.

Please address correspondence to Hendrik Janssen, MD, Ludwig-Maximilians-University Hospital, Neuroradiology, Marchioninistr 15, 81377 Munich, Germany; e-mail: hendrik.janssen@klinikum-nuernberg.de

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Table 1: Distribution of all aneurysms

	All					
	Mean	Median	Max	Min	SAH (%)	Unruptured (%)
University hospital ($n = 24$)	147.2	160	250	35	59	41
Maximum care hospital ($n = 22$)	94.8	80	400	30	47	53
Specialist hospital ($n = 9$)	89.6	38	420	30	35	65
All ($n = 55$)	117.3	100			53	47

Note:—Max indicates maximum; Min, minimum.

Table 2: Distribution of aneurysms presenting with SAH (AASAH)

	All SAH				Endovascularly Treated SAH				
	Mean	Median	Max	Min	%	Mean	Median	Max	Min
University hospital	87.0	80	150	35	62	53.6	50	100	20
Maximum care hospital	45.3	50	100	15	71	32.5	30	75	10
Specialist hospital	30.6	26	63	15	84	25.4	23	57	7
All	61.6	60			66	40.8	24		

Note:—Max indicates maximum; Min, minimum.

Table 3: Distribution of unruptured aneurysms

	All Unruptured				Endovascularly Treated Unruptured				
	Mean	Median	Max	Min	%	Mean	Median	Max	Min
University hospital	60.2	60	130	0	52	31.3	30	70	0
Maximum care hospital	49.5	30	300	5	75	37.0	21	200	0
Specialist hospital	59.0	18	357	10	88	51.6	15	323	7
All	55.7	62			66	36.6	51		

Note:—Max indicates maximum; Min, minimum.

be administered in an anonymous fashion, and no identification of the participating hospital could be inferred. Self-addressed prepaid envelopes were enclosed.

All questions were designed to obtain the current state at the participating institution. Thirteen questions were multiple-choice, and 2 questions were open-ended. Questions concerning neurosurgical services were also surveyed through the addressed neurointerventionalist. Patient data were sought on a population level; no individual patient data were required.

Forty-three nonuniversity neuroendovascular departments in Germany were identified through the membership roster of the German Professional Organization of Neuroradiologists. Beyond these, we sent the questionnaire to all 31 German university departments of neuroradiology. The questionnaires were sent in June 2014 and were addressed to the head of department/neurointerventional services.

All addressees were informed about anonymity and given instructions for completion by a separate cover letter. Participants were asked to answer the questions for "average patients with aneurysm-induced SAH." Patients with space-occupying intracranial hemorrhage (ICH), recurrent events during the preceding days, and vasospasm-related symptoms were excluded. Responses were received within 6 months.

We performed all statistical analyses by using SPSS Statistics 22 (IBM, Armonk, New York). Comparison between groups was evaluated with the χ^2 test. Statistical significance was assumed at $P < .05$.

RESULTS

Characterization of Participating Hospitals

Question 1 asked for the type of hospital, with choices among university hospital, maximum care hospital, or specialist hospital/other. A maximum care hospital provides all medical specializations. It differs from a university hospital mainly by not having an affiliation with a medical school. However, aneurysm treatment in Germany is not necessarily exclusively provided in the largest hospitals. Centers might have a focus on the treatment of neurologic disorders while not providing the full range of medical specializations. Also, many hospitals provide only a limited number of medical specializations for other reasons. Therefore, the category "specialist hospital/other" was introduced in the questionnaire. Questions 2 and 3 were the only open-ended questions in the questionnaire and asked for the number of aneurysms treated per year, on average, at the institution, with patients presenting with and without AASAH in total and by endovascular services, respectively. Question 4 asked about neurosurgical clipping as a treatment option at the institution.

The overall response rate was 74% through 55 completed questionnaires. The response rate of university hospitals was 77% (24/31) and of nonuniversity hospitals, 72% (31/43).

The group of participating nonuniversity hospitals consisted of 22 maximum care hospitals and 9 specialist/other hospitals. In 4/9 of specialist hospitals, endovascular treatment but no neurosurgical clipping was available. In the remaining institutions, both options were routinely performed.

The sum of all reported aneurysms treated neurosurgically and endovascularly per year by the participating hospitals in the survey was 6335.

The median number of treated aneurysms per year in total (AASAH + unruptured) was 100 per hospital (range, 30–420). Patients with AASAH compose, on average, 53% of all patients. The median number of treated patients with SAH in all hospitals was 60 (range, 15–150) (Table 1).

In the group of specialist hospitals, 1 center reported 420 aneurysm treatments per year, while the other 8 hospitals in this group only had 30–70 aneurysm treatments in total.

Sixty-six percent of all aneurysm treatments (SAH and unruptured, respectively; $P < .001$) were treated endovascularly. At university hospitals, the rate was 62%; at maximum care hospitals, 71%; and in specialist hospitals, 86%. Corrected for the 4 institutions that did not provide aneurysm clipping, the rate was 84% in specialist hospitals (Tables 2 and 3).

Quartiles for the total number of aneurysm treatments and endovascular treatments according to hospital type are provided in Table 4.

Questions 5 and 6 dealt with the process flow at the participating hospital. While question 5 asked for the total number of neurointerventionalists at the institution, question 6 asked for the decision-making process in SAH aneurysm treatment concerning the decider of the treatment strategy. The multiple-

Table 4: Institutional characteristics by quartiles of all aneurysms and endovascularly treated aneurysms

Quartile	Q All (No.)	Q Ev (No.)	University (No.)		MaxCare (No.)		Special (No.)	
			All	Ev	All	Ev	All	Ev
1	<48.8	<31	1	2	7	7	6	4
2	48.8	31	6	5	7	5	2	4
3	100	58	6	8	7	6	0	0
4	162.5	110	11	9	1	4	1	1

Note:—Q, quartiles; Ev, endovascular; University, university hospital; MaxCare, maximum care hospital; Special, specialist hospital.

Table 5: Interventionalists per hospital

	No. of Interventionalists					
	1	2	3	4	>4	M
University hospital	0	4	8	9	3	4
Maximum care hospital	4	9	4	4	1	2
Specialist hospital	0	7	1	0	1	2
All	4	20	13	13	5	3

Note:—M indicates median.

Table 6: Last time of day when treatments are started

	Starting Time				
	6 PM	7 PM	8 PM	9 PM	After 9 PM
Endovascular					
University hospital	3 (13%)	0	13 (54%)	5 (21%)	3 (13%)
Maximum care hospital	3 (14%)	2 (9%)	10 (45%)	4 (18%)	3 (14%)
Specialist hospital	3 (33%)	1 (11%)	4 (44%)	0	1 (11%)
All	8 (16%)	3 (5%)	27 (49%)	9 (16%)	7 (13%)
Neurosurgery					
University hospital	7 (29%)	1 (4%)	12 (50%)	2 (8%)	2 (8%)
Maximum care hospital	8 (36%)	2 (9%)	7 (32%)	2 (9%)	3 (14%)
Specialist hospital	2 (40%)	0	2 (40%)	0	1 (20%)
All	17 (35%)	3 (5%)	21 (38%)	4 (7%)	6 (11%)

choice options were either a decision by the neurointerventionalist or neurosurgeon alone or by a conjoint interdisciplinary decision.

In 85% of all hospitals, the mode of treatment was routinely decided by a consensus of both neurointerventionalists and neurosurgeons. In 9% and 5% of hospitals, treatment decisions were made alone either by the neurointerventionalists or the neurosurgeons, respectively. Differences were seen between types of hospitals: An interdisciplinary treatment consideration was preferred by 88% of the university hospitals. In the remaining 12%, the neurosurgeons were responsible. In nonuniversity hospitals, an interdisciplinary approach was pursued in 84%. In contrast, in the remaining 16% of hospitals, the neurointerventionalist decided alone.

The number of neurointerventionalists capable of treating AASAH is, on average, higher in university hospitals compared with nonuniversity hospitals (Table 5).

Management Considerations

Questions 7 and 8 asked whether aneurysms were treated at any time during the night by endovascular or neurosurgical services, respectively. Questions 9 and 10 asked for the last time of day when aneurysm treatment is started at the institution by neurointerventionalists or neurosurgeons, respectively (Table 6). Questions 11 and 12 asked whether aneurysms are treated on weekends at the institution by neurointerventionalists or neurosurgeons, respectively.

Table 7: Grouped starting times

	% to Start Until					
	7 PM	P^a	8 PM	P^a	9 PM	P^a
Endovascular						
University hospital	13	.15	67	.55	88	.97
Nonuniversity hospital	29		74		87	
All	21		70		86	
Neurosurgery						
University hospital	33	.38	83	.43	91	.26
Nonuniversity hospital	51		84		91	
All	40		78		85	

[a] χ^2 test.

Table 8: Grouped mean number of interventionalists for treatment starting times

	No.
All until 7 PM	2.4
All until 8 PM	2.8
All until 9 PM	2.8
After 9 PM	3.7

Of all 55 participants, only 1 university hospital reported providing endovascular and neurosurgical aneurysm treatment throughout the entire night on a regular basis for average SAH cases. All other hospitals did not consider routine treatment at night. However, 13% of the university and nonuniversity hospitals did start endovascular treatment after 9:00 PM. In both groups, most set the timeline at 8:00 PM (university, 54%; nonuniversity, 45%) (Table 7).

The share of institutions starting neurosurgical clipping up to 8:00 PM was 83% (university) and 84% (nonuniversity), respectively. Particularly, institutions that set the timeline for treatment before 7:00 PM were more frequent in neurosurgery (university, 33%; nonuniversity, 51%) than in endovascular therapy.

The later treatments are started, the more interventionalists are available at the hospitals (Table 8).

All hospitals (100%) provide endovascular aneurysm treatment for SAH on weekends, and 96% of all hospitals with a neurosurgical unit provide clipping on weekends for SAH. One university hospital and 1 maximum care hospital reported not providing neurosurgical treatment on weekends.

Diagnostics in AASAH

Finally, questions 13–15 dealt with aneurysm treatment–related diagnostics. Question 13 asked whether a DSA was performed at any time during the night after admission of a patient with AASAH, even if treatment would not take place during the night. Moreover, question 14 asked for the last time of day that a DSA would be started, even if treatment would take place only on the following day. While multiple-choice answers offered times from "6:00 PM" to "after 9:00 PM" by the hour, a possible answer was also "DSA is not performed on the day of admission, only directly preceding treatment" if treatment takes place on the following day. Question 15 asked for the modalities used for imaging control following neurosurgical clipping.

Seven percent of all participants answered that DSA is always performed immediately at any time throughout the night, even if

Table 9: Time of day to start diagnostic DSA if treatment is scheduled for the following day

	% Started						
	At Night	Not at All	6 PM	7 PM	8 PM	9 PM	After 9 PM
University hospital	13	58	4	0	13	8	17
Maximum care hospital	5	50	9	5	9	14	14
Specialist hospital	0	44	11	11	22	0	11
All	7	53	7	4	13	9	15

Table 10: Imaging control of clipped aneurysms[a]

	% of Controls			
	No Control	CTA	DSA	MRA
University hospital	13	21	88	4
Maximum care hospital	14	18	82	14
Specialist hospital	20	0	60	20
All	14	18	82	10

[a] Multiple answers possible.

treatment is performed only on the following day. Four of these are university hospitals (13% of all university hospitals), and 1 is a maximum care hospital (3% of all nonuniversity hospitals).

Most responders in all 3 hospital groups stated that a DSA is performed only in the context of treatment (all, 53%; university, 58%; maximum care, 50%; specialist hospital, 44%). If the time of day led to a postponement of treatment to the following day, DSA would also only be performed the next day (Table 9).

DSA is the most commonly used technique (all, 82%; university, 88%; nonuniversity, 78%) to control treatment results after neurosurgical clipping (Table 10). Some institutions gave multiple answers to this question. CTA was used in 18% (all); and MRA, in 10% (all). Fourteen percent reported not performing any imaging control after neurosurgical treatment (university, 13%; nonuniversity, 15%). Responses to this question were corrected for the 4 institutions that did not provide neurosurgical clipping.

DISCUSSION

Our survey was performed with the intention of documenting current clinical practice in diagnostic- and treatment-related aspects of acute aneurysmal SAH in Germany. With the high response rate of 74% including 77% of all German university hospitals, the survey is considered representative. Particularly, the comparison of all reported aneurysms in our survey with the total aneurysm treatment number in Germany[13,14] shows that about 88% of all aneurysm treatments in Germany are represented by this survey. Ten years ago, Sakowitz et al[2] published a German neurosurgical survey mainly emphasizing the clinical aspects of SAH management. To our knowledge, our article is the first survey to report the status quo with a focus on treatment-logistics of AASAH.

Indications are that the treatment volume of hospitals might have relevance for outcome parameters.[15-17] Such data were not included in our analysis, but the correlation of case load and hospital type is analyzed (Table 4) by our quartile calculation. In our study, more than half of all aneurysm cases (56%; AASAH + unruptured) were reported by university hospitals, though nonuniversity institutions were represented more frequently (31 versus 43 institutions; $P = .017$). Accordingly, 11 university hospitals and only 2 nonuniversity hospitals belonged to the upper quartile (quartile 4) of treatment providers. Moreover, the number of neurointerventionalists capable of endovascular AASAH treatment was also higher in university hospitals. Overall, most (88%) aneurysm treatments took place in university facilities or maximum care hospitals. Only a minor portion (12%) of patients seemed to be treated in specialist or other hospitals. We believe this finding is because cerebral aneurysm treatment demands a very high level of specialization and equipment, even beyond the core disciplines of neuroradiology and neurosurgery. Also, intensive care and departments for neurology and physiotherapy need to be equipped for patients with SAH.

Apparently, only a few hospitals (9 in the survey) in Germany fall into the category "specialist hospital/other," meeting all these requirements. However, 1 hospital in this group reported 420 aneurysm treatments per year and is, thereby, the center with the highest case volume in the survey. The high treatment number in this center causes heterogeneity in the group "Specialist hospital/other" because the treatment number of the other 8 hospitals in this group ranged in the lower 3 quartiles (Table 4). Nevertheless, this 1 center shows that a high case volume is not necessarily restricted to a university or university-like hospital.

Today more aneurysms are treated endovascularly in Germany than by neurosurgical clipping ($P < .001$). Our data show a coiling rate of 66% for AASAH and unruptured aneurysms (Tables 2 and 3). Ten years ago, endovascular treatment accounted for 46% of patients with AASAH.[2] Our numbers are in concordance with current guidelines, which also favor coiling over clipping if both procedures are considered equally applicable.[9,11,12] Comparing hospital categories, we observed that the share of clipped aneurysms is larger in university hospitals than in nonuniversity hospitals (Tables 2 and 3). An explanation could possibly be the role of university hospitals in the training of fellows. The share of clipped aneurysms could be larger to achieve sufficient training capacity for both specializations. Another possible explanation could be a higher grade of subspecialization of staff in university hospitals. The likelihood that vascular neurosurgery is not a key focus in nonuniversity hospitals could be greater.

Incomplete obliteration of the aneurysm is strongly associated with the risk of rebleeding.[18] While a final imaging control by DSA is immanent to the endovascular treatment method, imaging strategies to control the degree of occlusion after clipping are not consistent. While almost 82% (88% of universities) conduct control DSA after clipping, 14% still do not perform any imaging control at all after clipping. The number of centers that do not perform this imaging control has declined dramatically during the past 10 years.[2] This surprising paradigm shift can possibly be explained by the growing importance of quality assurance and legal considerations, owing to increasing numbers of malpractice lawsuits. It could also be the result of evolved and improved endovascular techniques today that open a spectrum of retreatment options for insufficient obliteration after neurosurgical clipping that did not exist in the past. MRA is the least used technique for clipping controls. This might be due to the artifacts caused by clip material resulting in limited imaging quality.[19]

All guidelines[9,11,12] recommend an interdisciplinary decision-making process for aneurysm treatment, with critical involvement of both endovascular interventionalists and vascular neuro-

surgeons. On this point, almost (85%) all hospitals followed this recommendation.

One of the main intentions of this survey was to document the status quo in temporal aspects of AASAH treatment. Remarkably, all participating institutions, even those with only 1 or 2 interventionalists, also provide full endovascular treatment on weekends. Weekend coverage in neurosurgery is almost as high (96%), with 2 hospitals not providing clipping on weekends.

The overwhelming majority (98% each, $P < .001$) do not treat patients with AASAH during the night, either endovascularly or neurosurgically. Not treating "average patients with AASAH" at night is the standard in Germany.

We believe that the explanation for this finding is the fear of higher complication rates when neurosurgeons and interventionalists perform the delicate procedure of aneurysm repair under difficult circumstances. The literature strongly supports this belief. Different reports show that complication rates in medical procedures are higher at night.[20-22] Furthermore, in many studies of aircraft pilots, it has been proved that fatigue has a negative effect on their error probability and error management.[23-26] Both are crucial determinants in aneurysm treatment as well, and these data can probably also be applied to neurosurgeons and interventionalists, though so far the possibility has never been studied explicitly for aneurysm treatment, to our knowledge.

Most hospitals do not start AASAH treatment later than 8:00 PM. Universities tend to start later than nonuniversity hospitals. This finding seems to be because more interventionalists are available at the hospital when treatments are started later (Table 8). It seems comprehensible that more staff resources allow a higher flexibility in interventions late in the evening because it is easier to respect rest periods on the following day. Neurosurgical treatment tended to be postponed to somewhat earlier the following day. The postponement might be explained by longer procedure times and limited availability of intraoperative neuromonitoring in the evening hours.

Divergent from the policy of not treating ruptured aneurysms at night, a minority of 7% performed diagnostic DSAs at night even if the treatment was not until the following day. The largest group (53%, all; 58%, universities) stated, however, that they do not perform DSA if treatment is scheduled for the following day, regardless of time of day. To us, this approach makes the most sense because it supports minimal movement of untreated patients with AASAH and avoids an additional transport of patients between the intensive care unit and the angiography suite, particularly if the patient is finally treated endovascularly. Only 24% of all centers would start a diagnostic DSA after 8:00 PM.

Limitations

The questionnaire was sent to the leading neurointerventionalist at each hospital. Whether the answers were given separately or in consensus by the neurointerventionalist and the neurosurgeon was not surveyed. The lack of information about the manner of answering is considered a potential source of bias.

Twenty-six percent of all addressed hospitals did not respond. Comparison of the number of all reported aneurysms in our survey with the total number of all treated cerebral aneurysms in Germany shows that the 26% of nonresponding hospitals account for approximately 12% of all aneurysms in Germany. The management practice in AASAH in these hospitals remains unknown in this survey.

The questionnaire did not allow evaluation of average time intervals between aneurysm rupture and treatment. A substantially higher effort would have been necessary by the participating hospitals to survey this information, and the authors expected a relevant decline in the willingness to participate in the survey if this information were sought.

CONCLUSIONS

Our survey gives a detailed summary of the current practice in endovascular treatment of acute aneurysmal SAH and related topics in Germany. It reveals both similarities and differences in AASAH management among treatment-providing hospitals. Today most aneurysms in Germany are treated endovascularly, and university hospitals have a key role in AASAH treatment.

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