Influence of Recanalization on Outcome in Dural Sinus Thrombosis
A Prospective Study

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Background and Purpose—Recanalization in dural sinus thrombosis (DST) has been observed previously; however, systematic prospective data are lacking. The influence of recanalization on DST outcome has not yet been thoroughly evaluated.

Methods—Thirty-seven consecutive patients with DST were prospectively examined. Neurological deficits were graded with the National Institutes of Health Stroke Scale (NIHSS) on hospital admission and discharge. Functional outcome was assessed with the modified Rankin Scale (mRS) on hospital discharge and after 12 months. All patients were treated with intravenous heparin in the acute stage of illness, followed by oral anticoagulation for 12 months. Imaging follow-up with MR angiography and, in a few cases, with CT or conventional angiography was performed on hospital discharge and after 6 and 12 months.

Results—Twelve-month functional outcome was excellent in 89% of patients with an mRS of 0 or 1. A recanalization rate of 60% was already observed on hospital discharge (22±6 days); thereafter, recanalization rates increased insignificantly. Early recanalization was not related to NIHSS score on hospital discharge or an mRS of 0 on discharge or after 12 months.

Conclusions—We found a high frequency of early recanalization but without influence on clinical outcome parameters. Frequent imaging follow-ups in DST are not useful because they provide no information on patient outcome. (Stroke. 2004;35:544-547.)

Key Words: computed tomography ■ magnetic resonance imaging ■ outcome ■ recanalization ■ sinus thrombosis, intracranial

In ischemic arterial stroke, early spontaneous recanalization of occluded intracranial vessels is associated with improved short- and long-term outcome.1-2 This is the basis for thrombolytic stroke therapy.3-5 Disturbances of cerebral venous drainage because of dural sinus thrombosis (DST) may lead to reversible localized or generalized brain edema, or, when thrombosis extends to cortical veins, to venous infarcts.6-9 In several case series and retrospective studies, recanalization phenomena in DST have been observed.10-16 Although it appears unlikely that in most patients with DST spontaneous recanalization occurs during the first few hours after thrombosis onset, MRI studies show that venous infarcts are quite different from arterial stroke.11-13 So even late recanalization may have an impact on clinical outcome. We examined the influence of recanalization in DST on clinical outcome in a prospective study.

Patients and Methods
Thirty-seven consecutive patients with DST (30 women, 7 men; mean age, 40±17 years) were prospectively enrolled in this study. Informed consent was obtained in all cases, and the study was conducted according our institutional ethical guidelines. Table 1 summarizes important demographic and clinical data of the patient cohort. Patients with isolated cortical venous thrombosis were excluded, because recanalization of cortical veins cannot be assessed reliably with MRI. Diagnostic procedures on admission consisted of conventional digital subtraction angiography (DSA) in 12 cases, MRI and venous MR angiography in 34 cases, and CT and venous CT angiography (CTA) in 1 case, with 12 patients receiving ≥1 diagnostic procedure. Patient management followed an internal institutional protocol regarding treatment and follow-up. All patients received intravenous heparin in the acute stage of illness without bolus application with the partial thromboplastin time at least doubled (70 to 90 seconds), followed by oral anticoagulation for 12 months. Clinical and imaging follow-up was performed regularly in all patients at hospital discharge (mean latency from admission, 22±6 days; MRI and MR
angiography in all cases), after half a year (mean latency, 183±41 days; MRI and MR angiography in all cases), and after 1 year (mean latency, 370±41 days; DSA in 2, MRI and MR angiography in 31, and CTA in 2 patients).

Clinical Evaluation
Neurological deficits on admission and discharge were graded with the National Institutes of Health Stroke Scale (NIHSS). The NIHSS has the advantage that bilateral deficits can be assessed. Functional clinical outcome was assessed with the modified Rankin Scale (mRS) on hospital discharge and after 12 months. Clinical evaluations were performed by a neurologist.

Neuroradiological Evaluation
The imaging parameters for MRI, venous MR angiography, and CTA are summarized in the Appendix. Because the transverse sinus is frequently subject of normal variants, transverse sinus thrombosis was diagnosed only when a T1-hyperintense signal on MRI corresponding to a blood clot was obtained or recanalization was apparent on follow-up. In a first step, we distinguished between complete, partial, and no recanalization for each thrombosed venous vessel at the time of follow-up. No recanalization was assumed when the flow signal still was interrupted (Figure 1). Partial recanalization was defined as a flow signal suggestive of a residual luminal narrowing of at least 50%. For complete recanalization, the previously affected sinus needed to display an uninterrupted flow signal with a residual luminal narrowing of <50% (Figure 2). Because >1 venous vessel was thrombosed in most patients, for comparison with the clinical data, overall complete recanalization was assumed when all previously affected sinuses needed to display an uninterrupted flow signal with a residual luminal narrowing of <50% (Figure 2). Because >1 venous vessel was thrombosed in most patients, for comparison with the clinical data, overall complete recanalization was assumed when all previously thrombosed structures met the criteria of full recanalization; overall partial recanalization, when at least 1 vessel displayed partial recanalization; and no recanalization, when all thrombosed vessels were not recanalized. In the same way, imaging data were reviewed by a second observer blinded to the results of the first reading, evaluating agreement on overall recanalization.

Figure 1. Time course in a case of transverse sinus thrombosis without recanalization. A, MRI on admission. I, T1-weighted sequence with left temporal hypointensity. II, Left temporal signal hyperintensity on T2-weighted sequence. III, Slight diffusion abnormality on diffusion-weighted imaging. IV, MR angiography with left-sided transverse sinus thrombosis. MR angiographies on days 20 (B), 150 (C), and 382 (D) without recanalization of the occluded transverse sinus.

Figure 2. Time course of recanalization in a patient with superior sagittal sinus thrombosis.
### Statistical Evaluation

Absolute frequencies were analyzed with a $\chi^2$ test or, when appropriate, Fisher’s exact test. For comparison of the NIHSS at different time points, a nonparametric $U$ test was used. A possible relationship between NIHSS and recanalization was assessed by Spearman’s rank correlation. A possible relationship between the time from onset of first symptoms to diagnosis in days and recanalization on hospital discharge was also evaluated by Spearman’s rank correlation. Interobserver agreement for the 2 readers of the imaging data were analyzed by the intraclass correlation coefficient (ICC).

### Results

The median NIHSS on admission was 4.0 (range, 0 to 27). Most patients had significantly improved already on hospital discharge (median, NIHSS, 1; range, 0 to 12; $P<0.001$). No fatal course of DST occurred in this series. A further significant functional improvement was apparent after 12 months ($P<0.05$), with 89% of patients reaching an mRS of 0 or 1 (Table 2). A significant correlation was found for the initial NIHSS and a combined thrombosis of ≥2 sinuses (Spearman’s rank correlation coefficient [SRCC], 0.33; $P<0.05$) and for straight sinus (SRCC, 0.41; $P<0.05$) and internal cerebral vein thrombosis (SRCC, 0.43; $P<0.01$). Beyond that, no association between the initial NIHSS and site of thrombosis was found. Patients with coagulopathy tended to have initially higher NIHSS (SRCC, 0.33; $P<0.05$) but not a higher frequency of combined (≥2) DST.

Recanalization rates are summarized in Table 2. Recanalization rate was highest for the superior sagittal sinus, followed by the internal cerebral veins, straight sinus, and transverse sinus; it was lowest for the sigmoid sinus. Although recanalization rates for individual sinuses and the overall recanalization rate tended to increase with time, this trend did not reach statistical significance. No differences for individual recanalization rates were found for thrombosis of a single venous vessel or a combination with thrombosis of other sinuses.

Interobserver agreement for overall recanalization was good, with an ICC of 0.72 (95% confidence interval [CI], 0.67 to 0.77; $P<0.001$). It was best for agreement on full recanalization (ICC, 0.89; 95% CI, 0.85 to 0.89; $P<0.001$) and lowest for assessment of partial recanalization (ICC, 0.45; 95% CI, 0.29 to 0.59; $P<0.01$). On hospital discharge (mean latency from admission, 22±6 days), ≈60% of patients already showed complete or partial overall recanalization. We observed a nonsignificant trend for a long time interval from symptom onset to diagnosis and a lower recanalization frequency on hospital admission (SRCC, −0.28, $P=0.09$).

Neither partial nor full early overall recanalization was correlated with the NIHSS on hospital discharge or associated with the frequency of mRS=0 patients on hospital discharge and after 12 months. Early recanalization rates were not different for patients with or without coagulopathy.

### Discussion

DST is not as rare as previously thought. With improved noninvasive imaging techniques such as MRI, MR angiography, and CTA, the awareness of only slightly affected patients with DST has increased. Although recanalization phenomena in DST have been observed in retrospective studies,10-18 little is known about the time course of recanalization in DST and its effect on outcome.

In this prospective study, all patients were treated according to an internal institutional guideline with intravenous unfractionated heparin, with the partial thromboplastin time at least doubled in the acute stage of illness, followed by 12 months of oral anticoagulation. Although intravenous heparin treatment is widely accepted and is supported by at least 1 controlled trial,17 the optimal duration of oral anticoagulation remains unclear because so far no controlled trials have been conducted and opinions are based largely on data gathered from deep venous leg thrombosis and pulmonary embolus trials. Neither heparin nor oral anticoagulants pharmacologically possess thrombolytic
action, so the rationale for treatment is to prevent recurrent thrombosis and appositional thrombus growth. Data from this study show that DST patients display a high spontaneous and intrinsic thrombolytic potential, with recanalization rates of 60% during the first 20 days. Thereafter, recanalization rates increase insignificantly. Recanalization rates for individual venous structures are in line with those reported in the only other prospective study by Baumgartner and coworkers. In that study, no analysis of recanalization and outcome data was attempted. In a retrospective case study with unsystematic follow-up, Strupp et al. found a higher frequency of residual deficits in patients without recanalization than in patients with complete or partial recanalization. We found no such impact of recanalization on either short- or long-term outcome after 12 months, so this finding is likely due to varying observation periods. In a recent prospective study, venous hemodynamics assessed by venous transcranial duplex sonography was found to be related to outcome. In that study, the extent and hemodynamics of venous collaterals were examined. Our data may imply that the extent and function of venous collaterals at the time of thrombosis are probably more important than recanalization occurring days (up to months) after onset of DST. We cannot comment on the potential effectiveness of early recanalization by local thrombolysis; none of our patients received thrombolytic treatment. The clinical implication that can be drawn from our data is that frequent imaging follow-up after DST treated with heparin and oral anticoagulation is not useful concerning recanalization because it does not provide helpful information regarding patient outcome.

The 12-month outcome of our patients was excellent and comparable with that of previous prospective outcome data, so our cohort seems to be representative compared with patient series reported by others.

This study has limitations. In the vast majority of patients, 2-dimensional time-of-flight MR angiography with 3-dimensional maximum intensity projection was used. This technique has excellent agreement with conventional DSA. However, we cannot exclude that very slow venous flow was not detected and mistaken as occlusion. Despite the high agreement of CTA with DSA and MRA, a similar problem may have been encountered in the few patients who received CTA. The grading system used is semiquantitative and may be influenced by mistakes. However, no generally accepted grading system for DST has been developed yet.

### Appendix

**MR angiography:** 1.5-T Signa MRI unit (General Electrics). Spoiled gradient echo sequence (2-dimensional time of flight); flip angle, 50°; bandwidth, 15.63; slice thickness, 1.5 mm; and field of view, 26 cm. Caudal presaturation of arterial flow from neck arteries. Reconstruction of 3-dimensional images with maximum intensity projection.

**CTA:** Spiral CT unit (General Electrics). Variable pitch (2.0 to 2.5). Scanning, 120 kV; maximum tube current, 220 mA; field of view, 23 cm. Total of 100 mL nonionic contrast medium injected at a rate of 3 mL/s into an antecubital vein. Prescan delay, 40 seconds; scan duration, 60 seconds. Prospective images reformatted to images with 1-mm collimation and transferred to a workstation for 3-dimensional reconstruction.

### References

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