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LETTER TO THE EDITOR

Computerized angiographic evaluation of coil density and occlusion rate in embolized cerebral aneurysms

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The recently published article by Kang et al. [3] is a timely and important contribution to our understanding of the mechanisms of rebleeding in cerebral aneurysms. We nonetheless wish to add the following comments:

To determine the success of embolization, Kang et al. calculate angiographic "coil density" (CD) as according to methods earlier described by Tamatani et al., and which we and others have previously employed [5, 7, 8]. Simplistically, the aneurysm's total volume is first calculated assuming an ellipsoid aneurysm shape; coil volume is calculated as a summation of cylindrical coil shapes (calculated angiographic coil density thus expressed as a percentage of all coil volumes within the estimated aneurysm volume). While recognizing several limitations and drawbacks of this mathematical approximation, Kang et al. nevertheless concluded that calculated CD was the only available objective measurement to estimate acceptable coil embolization at the time of their data registration. We strongly disagree in that point:

As in our study which the authors cite, we proved the invalidity of this parameter [5]. We compared angiographic calculated CD with direct measurements of CD in corresponding histologic ground sections. These histometric evaluations allow for calculation of intraaneurysmal morphology using the highest currently available resolution [1, 4]. We found a statistically significant difference between angiographic CD and histometric CD with differences of more than 10% in four out of 14 aneurysms. In 12 out of 14 aneurysms angiographic values were higher than the corresponding "real" histometric CD values. Our data clearly suggests that angiographically calculated CD is not only inaccurate, but could potentially result in patient harm if this (often over-) estimation of aneurysm size were used to guide clinical decision making.

When hypothesizing as to possible reasons for early aneurysm rebleeding, Kang et al. cite uneven coil distribution and inter-coil-loop thrombolysis. We would like to add two additional possibilities: a major cause for rebleeding of "successfully" embolized aneurysms (Roy Class 1 and 2) may be the tendency of subjective overestimation of occlusion rates. This has been shown in the above-cited paper which compared subjective occlusion rate estimations with a new method of computerized occlusion rating (COR) [5]. In ten of 14 aneurysms, computerized measurements of COR were 5–15% lower than subjective estimations. This is potentially dangerous especially in cases of COR Roy Class 3 aneurysms (residual filling of the aneurysm neck and dome) whereby subjective overestimation may lead to misclassification as Roy Class 2 (residual filling within the aneurysm neck only). The major reasons for superiority of COR over subjective estimations were (1) the better definition of the aneurysm border using computerized

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image superimposition of pre- and post-embolization images and (2) the higher resolution power of the intraaneurysmal contrast medium gray values. Subjective occlusion rate estimation is not that precise in intraaneurysmal contrast medium gray value recognition. This results in subjective underestimation of smaller contrast medium-filled intraaneurysmal areas, leading to falsely high subjective occlusion rates. As initial occlusion rate is a powerful predictor of aneurysm recanalization and rebleeding [2], we want to emphasize the clinical importance of minimizing this subjective bias, ideally by objective three-dimensional COR in prospective series or at a minimum with two-dimensional COR for retrospective evaluations.

Finally, in an experimental autopsy study using a rabbit aneurysm model, we compared angiographic and corresponding histologic findings using COR [6]. In the animal sacrificed at 1 h post-embolization, we found 80% angiographic COR compared with only 32.6% histometric COR. This wide discrepancy between the two methods is thought to be due to DSA's insensitivity to blood stasis, instead displaying the contrast medium flow only. In clinical practice, there is usually no blood flow inside the aneurysm after embolization because the coil construct completely obstructs the contrast medium inflow, as seen on the respective DSA. This is initially interpreted as complete or near-complete aneurysm occlusion and the clinical aim appears to be realized. But extremely low "real" histometric occlusion at this early time point is revealed by the histological ground section in our specimen. Consequently, we cannot expect stable thrombus formation and thus safe aneurysm occlusion in the first hours after embolization. Any factor leading to changes of intraaneurysmal blood flow (e.g., elevated blood pressure, or changing shear stress patterns, particularly in the region of the aneurysm neck) may theoretically lead to early rebleeding. It is our hope that future studies will better elucidate the role of these underlying hemodynamic issues on post coil-occlusion aneurysmal rebleeding rate.

Conflicts of interest None.

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