REPLY:

We applaud the advanced and multidirectional studies performed by Wetzel et al[1] and Meckel et al.[2] We agree with Meckel et al,[2] who showed that aneurysms with an irregular shape or a high aspect ratio may have complex and unstable flow.

In our study,[3] we differentiated vortex core lines from vortex cores. We identified vortex cores as thin streamline bundles with minimum velocities by progressively decreasing a threshold to visualize flow streamlines with velocities under the threshold in aneurysms. In extremely low velocity thresholds, a vortex core was exhibited as a line. In our study, we did not include such lines into vortex cores, because we could not definitely discriminate the lines from irregular streamlines which were usually visualized in aneurysms via 4D flow MR imaging. In our study,[3] the velocity-encoding (VENC) for 4D flow MR imaging was set to 40–60 cm/s to correctly extract low-velocity vectors in aneurysms. We verified that the thin streamline bundle was a vortex core by showing that the bundle passed through the center of vortical flow vectors in the aneurysmal dome.[3]

Meckel et al[2] showed a vortex core line using an algorithm to identify the points on the face where reduced velocity is zero and to connect these distinct points.[4] However, the locations of vortex core lines can vary between algorithms.[3] In 4 of 5 aneurysms examined in their study, the VENC for 4D flow MR imaging was 90 cm/s to detect high-velocity flow components.[2] This VENC value can lead to errors in the extraction of flow vectors with low velocities in aneurysms, which may cause mislocations of the zero velocity points. Therefore, we suggest that it should be verified that their vortex core lines are located in the center of vortex flows in aneurysms. This verification would guarantee the usefulness of the tool integrating the algorithm to automatically identify vortex core lines in aneurysms and to avoid the interobserver differences. We hope that the tool helps to clarify the role of the vortical flow pattern in aneurysm behavior in future studies.

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