Intracranial aneurysms are small, balloon-like dilations that form in the walls of arteries in the brain. They are surprisingly common – they may occur in up to one in ten people – but most of them never cause symptoms and remain undetected. The problem arises when an aneurysm ruptures. This leads to bleeding into the space around the brain, called subarachnoid haemorrhage, which is a medical emergency with a high risk of death or severe disability. For this reason, aneurysms are usually seen mainly as a local vascular problem: a weak point in a single artery that may rupture.

However, recent research suggests that this picture may be incomplete. We now know that abnormal blood flow and chronic inflammation of the vessel wall play a key role in the formation and growth of aneurysms. Cells in the vessel wall are exposed to disturbed blood flow and mechanical stress, which leads to damage of the inner lining (endothelium). This damage attracts immune cells, especially macrophages, which enter the vessel wall and release inflammatory substances. Over time, this self-perpetuating inflammatory process may weaken the wall further and promote aneurysm enlargement.

Our previous clinical work in patients with unruptured intracranial aneurysms brought an unexpected observation. Even though their aneurysms had not ruptured, these patients showed subtle changes in brain structure, disturbances in large-scale brain networks and measurable problems with cognitive functions such as attention and memory. These findings raise an important and still unanswered question: can a “silent” aneurysm, through chronic inflammation of the vessel wall, affect the brain as a whole and contribute to long-term neurological and psychological problems?

The aim of this project is to explore this question in a controlled preclinical study using a rat model of intracranial aneurysm. In this model, aneurysms are induced by a combination of vascular surgery and increased blood pressure, which together reproduce the conditions that promote aneurysm formation in humans. Animals will be followed for several weeks, and the development and growth of aneurysms will be monitored with advanced magnetic resonance angiography. Special MRI techniques will be used not only to visualise the aneurysm itself, but also to assess inflammation of the vessel wall. In parallel, computer simulations of blood flow (computational fluid dynamics) will allow us to calculate how mechanical forces acting on the vessel wall change over time.

At the same time, we will regularly measure markers of inflammation and neuronal injury in the blood and cerebrospinal fluid, and we will test cognitive performance in tasks adapted for rodents. A key part of the project is the use of PET-MRI imaging with a specialised radiotracer that binds to activated microglia – immune cells of the brain. This will enable us to visualise and quantify neuroinflammation in vivo, in different regions of the brain, while the aneurysm is developing.

At the end of the experiment, we will perform detailed microscopic and molecular analyses of the brain and aneurysm tissues. This will allow us to link changes observed in imaging and blood tests with cellular and protein-level alterations in the vessel wall and brain.

By combining modern imaging, computer modelling, laboratory assays and behavioural tests, this project will provide the first comprehensive picture of how an unruptured intracranial aneurysm can influence the brain. The results will help to clarify whether chronic vascular inflammation associated with aneurysms may drive neuroinflammation and contribute to cognitive or psychiatric problems. In the longer term, this knowledge may support the development of new strategies for early diagnosis, risk stratification and targeted treatment in patients living with unruptured aneurysms.