The abdominal aorta tends to dilate in individuals over the age of sixty. This dilated aorta, known as aortic aneurysm (AAA), can result in a life-threatening hemorrhage when ruptured. Rupture of the aneurysm can be avoided by preventive surgery, however this is not without risk. Current guidelines for surgery are only based on the diameter and population statistics, which do not always apply for the individual patient. For some patients the aneurysm ruptures before surgery is recommended, while other aneurysms can remain stable and are currently exposed to unnecessary surgical risks. Therefore, a more personalized approach is required.

In this thesis, a method is developed that assesses the mechanical state of the AAA, rather than its size, using 3D ultrasound. Similar to a balloon that is overinflated, an aneurysm will rupture once the stresses in the wall outweigh the local strengths. The stiffness indicates to what extent the aneurysm can elastically deform, and the peak wall stress indicates the location and amount of stress that acts on the aneurysm wall. Major steps towards clinical applicability were made. First results from a large clinical study suggest that these metrics might have diagnostic value and provide alternative metrics to assess rupture risk.

Figure 1: Example of a 3D ultrasound acquisition of a healthy aorta (top left) and an aortic aneurysm (bottom left) with the representative aortic wall stresses (bottom right) and the location of the peak stresses (blue circles).

Figure 2: Peak wall stresses for aneurysm patients and healthy volunteers as function of the maximum aortic diameter (left). Patients are identified with low peak wall stress (green circles), while other patients have an elevated peak wall stress (red circle). Large differences are observed in aortic stiffness when aneurysm patients are compared with healthy volunteers (right).