# Chapter 2
# Anatomical Mapping of Intracranial Aneurysms:
## A CT-Based Framework for Precision Neurosurgery

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## ABSTRACT

*Intracranial aneurysms are a significant neurosurgical issue in low- to middle-income countries. This study evaluates a CT-based anatomical mapping system for enhancing surgical accuracy in cerebral aneurysm treatment. In a retrospective analysis of 82 patients operated in Karachi, Pakistan, at a tertiary care center. The female predominance of(65.9%) and high prevalence of hypertension (82.9%) were identified as major risk factors. All patients had acute hemorrhage and headache. CT scan enabled precise localization of aneurysms and showed statistically significant correlations between Glasgow Coma Scale (GCS) scores and locations of aneurysms ($p = 0.029$), and between seizure types and locations of aneurysms ($p = 0.003$). Cerebral infarction was also strongly correlated with the need for decompressive surgery (p < 0.001).*

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## 1. INTRODUCTION

Intracranial aneurysms present a serious neurosurgical challenge from their possible rupture and the subsequent occurrence of subarachnoid hemorrhage (SAH), usually with considerable morbidity and mortality associated (Wang et al., 2022). When the vascular anatomy is accurately assessed, the intervention strategy can be tailored, with special emphasis on complex neurovascular interventions. Computed tomography angiography (CTA) had transformed into an indispensable tool in this regard with noninvasive high-resolution three-dimensional imaging of the cerebral vasculature (Hacein-Bey et al., 2011). This approach helps in evaluating certain key morphological parameters like the size of an aneurysm, neck configuration, dome-to-neck ratio, and spatial relationship to parent and perforating arteries (Howard et al., 2019).

Technical improvements in CTA postprocessing—i.e., volume rendering, maximum intensity projection (MIP), and multiplanar reformation (MPR)—have significantly improved the visualization of tiny-caliber vessels and partially thrombosed aneurysms (Zhou et al., 2024). These improvements allow neurosurgeons to define better bony landmarks, aneurysm orientation, and neurovascular relationships, thereby enhancing surgical planning (Wang et al., 2021).

Recent advancements in the area of medical imaging and neurosurgical techniques have greatly influenced the diagnosis and treatment of complex brain conditions, especially related to the resection of brain tumors and vascular conditions. Vadhavekar et al. (2024) presents a great overview of the latest developments in imaging, and surgical approaches for the removal of brain tumors, including the use of intraoperative MRI, neuronavigation, fluorescence-guided surgery and robotic surgery. Together, these techniques have improved the accuracy, safety, and extent of tumor resection with improvements in patient outcomes and neurological deficits.

In parallel, the use of deep learning in neuroimaging has opened new possibilities for automatic detection of vascular pathologies, with very promising results. For example, Ueda et al. (2019) used artificial intelligence for automatic detection of cerebral aneurysm in MR angiography. They found that the accuracy was high enough that artificial intelligence may eventually be used clinically to help radiologists detect subtle aneurysms that would otherwise be missed in routine checks, thereby improving diagnostic accuracy. By improving speed and consistency, this may allow for a standard and scalable tool to detect early signs of pathology - a critical need for preventing disastrous events such as subarachnoid hemorrhage.

These studies are representative of a larger trend towards technology-enhanced neurosurgical care, in which artificial intelligence and real-time imaging enhance rather than replace clinical decision-making and operationalization of care (human computer systems). Neurosurgeons will increasingly adopt workflows that maximize

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