Social and Economic Issues in Imaging

Intracranial Aneurysms:

A Game of Millimeters

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Rationale and Objectives: In this review we will discuss the historic development of intracranial aneurysms as a pathologic entity and the potential for overdiagnosis.

Materials and Methods: We conducted a literature search to assess the prevalence, rupture rate, and treatment of intracranial aneurysms.

Results: Intracranial aneurysms represent a necessary example of overdiagnosis.

Conclusions: A change in the nomenclature of small aneurysms is a possible solution to mitigate patient anxiety from a diagnosis of intracranial aneurysm.

Key Words: Aneurysm; overdiagnosis; vascular imaging.

Since the 18th century, intracranial aneurysms were recognized by physicians as a silent scourge, which could kill indiscriminately. In 1927, when Moniz introduced cerebral angiography to the world, the diagnostic and therapeutic outlook of intracranial aneurysms changed forever (1). As with any technologic innovation, the moment a new medical diagnostic tool arrives, a rush to prove its utility and effectiveness ensues. Expectedly, cerebral angiography quickly became an integral component in the workup and identification of cerebral aneurysms (2). The study of intracranial aneurysms continued to grow, and clinicians required epidemiologic data to better understand the prevalence of this phenomenon and to develop appropriate treatment algorithms. A 42-year autopsy series published in 1958 by Housepian and Pool described the prevalence of aneurysms as 2% in adults (1). Approximately, 71% of identified aneurysms produced a fatal hemorrhage, which they subdivided into initial and subsequent bleeding episodes (1). Notably, 6.6% of ruptured aneurysms measured 1–2 mm and 38.7% of ruptured aneurysms measured 3–5 mm (1). More recently, the mean prevalence of intracranial aneurysms varies, being quoted as high as 5%–10% by Caranci et al. (3). The discrepancy in prevalence over time is likely multifactorial, with more inclusive characterization, larger data sampling, and an increase in imaging volume serving as contributing factors.

One factor which did not contribute to this increased prevalence is size criteria. The autopsy series by Housepian and Poole classified intracranial aneurysms according to the following criteria: 1–2 mm, 3–5 mm, 6–10 mm, 11–20 mm, 21–40 mm, >40 mm (1). The presence of aneurysms was based on alterations in the histologic morphology of the vessel wall as identified on microscopic section (1). Additionally, histologic changes were present at vascular bifurcations in keeping with the expected evolution of histologic changes associated with the development of aneurysms (1).

Currently, diagnosticians try their utmost to accurately identify the smallest of cerebral aneurysms on a variety of imaging modalities. Whether in the reading room or the angiography suite, they may question if a finding is real, but they do not question whether a 2-mm aneurysm is worth reporting.

This categorical approach harkens back to their training in pathophysiology, where they learned about the catastrophic consequence of aneurysm rupture. In their eyes, it is unacceptable to dismiss a 2-mm aneurysm with the aim of sparing the patient the psychological trauma of overdiagnosis, as this would constitute a preventable serious harm. As diagnosticians improve their ability to perceive and document a 2-mm aneurysm, perhaps they should ask themselves, now what?

EPIDEMIOLOGY OF CEREBRAL ANEURYSM RUPTURE

Though catastrophic, there is an approximately 0.006% chance of developing an aneurysmal subarachnoid hemorrhage each year, which translates to approximately 15,000 annual cases in the United States (4). For patients with a

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known aneurysm, the likelihood of rupture varies based in part on whether or not the patient suffered a subarachnoid hemorrhage from a separate aneurysm, anatomic location of the aneurysm, and the size of the aneurysm in question. Data published from the International Study of Unruptured Intracranial Aneurysms (ISUIA) in 2003 demonstrated that the lowest risk of aneurysmal ruptures occurs in patients anterior circulation aneurysms <7 mm in diameter the anterior circulation, without prior history of rupture (5). The overall risk for patients who have an aneurysm <7 mm in diameter without a prior history of rupture is approximately 0.1% per year (5). For aneurysms >10 mm in diameter, the rate of rupture increases to approximately 1% per year (4).

A review on the natural history of aneurysms performed by Brown and Broderick demonstrated that among retrospective studies, for unruptured aneurysms <10 mm in diameter, the risk of rupture is 0%–1.1% per year (6). For aneurysms >10 mm in diameter, the risk of rupture has been published as 0.7%–6.7% per year, noting the absence of an upper size limit in these studies (6). In Brown and Broderick's analysis of prospective studies on unruptured aneurysms, they noted that the 5-year cumulative rupture rate for aneurysms <7 mm in diameter was zero if they were in the anterior -circulation or in the cavernous carotid artery (6). Posterior circulation aneurysms, <7 mm in diameter, had a rupture rate of 2.5% (6). The rupture rates increased to 3.0% when the aneurysm grew to 13–24 mm in the cavernous carotid (6). Rupture rates were 2.6% and 14.5% in anterior circulation aneurysms that were 7–12 and 13–24 mm in diameter, respectively (6). Rupture rates were 14.5% and 18.4% in posterior circulation aneurysms that were 7–12 and 13–24 mm in diameter, respectively (6).

The seemingly benign course of small anterior circulation aneurysm came under scrutiny more recently, because of studies providing more detailed anatomic risk stratification. A retrospective review of the impact of aneurysm location on rupture risk by Gross et al. demonstrated that pericallosal and frontopolar aneurysms have an increased likelihood of rupture in comparison to more proximal anterior circulation aneurysms (7). The true anatomic predilection for rupture requires further research to fully quantitate, to account for small sample size.

Initial treatment evaluation for ruptured intracranial aneurysms demonstrated a 1-year morbidity and mortality risk of 12.6% with neurosurgical clipping and 9.8% with endovascular coiling (5). These risks vary based on patient age and aneurysm location (5). These values are difficult to extrapolate to unruptured aneurysms but are likely lower (6,8). The possibility of increased procedural risk in case of rupture can be used to justify early treatment of unruptured aneurysms.

Guidelines published by the Stroke Council state that because of the aformentioned risks associated with neurosurgical clipping or endovascular coiling, intervention for small asymptomatic aneurysms is not generally recommended (4,5). For aneurysms >10 mm, treatment should be strongly considered (4). In early 2014, PHASES, a new aneurysm risk calculator, was proposed to assess rupture versus treatment risk (9). The implications of this system and its impact on treatment recommendations have not yet been fully explored.

EVALUATION OF METHODOLOGY

Some of the discordance in the literature regarding the incidence of and natural history of aneurysms may reflect methodologic differences. Housepian and Poole's evaluation represents the only autopsy series. Therefore, its estimate of aneurysm incidence is generalizable to the entire population, but their work cannot be used to estimate the annual rate of rupture. The ISUIA, which used a prospective analysis of patients diagnosed with unruptured aneurysm, probably provides the best estimate of the natural history of aneurysm and mortality risk. However, this study excluded aneurysms <2 mm in diameter. The study by Gross et al., while provocative, may be confounded by factors related to its retrospective design (eg, survivorship bias and/or detection bias).

Moreover, aneurysms in early studies generally fell into the following classification categories: fusiform, saccular, luetic, and saccular with arteriosclerosis (1). More recent studies excluded fusiform aneurysms, thus at least partially limiting diagnostic correlation (5). Studies also differ in the extent to which they evaluate the distal vasculature (5,7). The evolution of these studies highlights how our current level of knowledge and technology frames our assessment of truth. Each study that further characterized vascular anatomy changed our perception of the occurrence of aneurysm rupture. This serves as a warning that although our data may at times appear complete, more representative studies along with more detailed anatomic evaluations always have the potential to disrupt our current diagnostic and treatment paradigm.

Given the minimal risk of rupture for incidental small aneurysms, patients should be told that despite the serious diagnosis, according to our current literature, no intervention is typically recommended. The large proportion of patients diagnosed with ultimately quiescent aneurysms compared to the few who will rupture, particularly in light of the lack of treatment options, suggests overdiagnosis. This premise of overdiagnosis, particularly with aneurysms <2 mm, is further corroborated by their absence from the ISUIA's analysis of the natural history and treatment of unruptured intracranial aneurysms.

THE COMPONENTS OF UNCERTAINTY IN A HEALTH CARE INTERACTION

A radiologist's practice revolves around uncertainty. Descriptions are often qualified: "diagnostic of," "compatible with," or "cannot exclude a particular disease entity" based on the level of uncertainty. Whether through conscious or subconscious effort, word choice communicates the level of