Non-random spatial clustering of spontaneous anterior cranial fossa CSF fistulas indicate weakness in the posterior cribriform plate

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Introduction

The anterior skull base is a common site for the development of spontaneous meningoceles, encephaloceles and meningopencephaloceles that can lead to cerebrospinal fluid (CSF) fistula formation. The etiology of spontaneous CSF fistulas often involves a combination of a chronic increase in intracranial pressure, either from idiopathic intracranial hypertension (IIH) or obesity and an anatomic predisposition or thinning of the cranial base adjacent to an area of pneumatization. In some cases the exact site of leak may be difficult to determine and especially in light of the progressive adoption of endoscopic techniques, localization becomes ever more crucial.1 Whether all sites in the anterior skull base are equally prone to fistula formation or whether they are distributed randomly throughout the anterior skull base is unknown. Various authors have proposed the anterior cribiform plate and the anterior portion of the fovea ethmoidalis as the sites most frequently involved.2,3,4 However no study to date has examined the actual distribution of anterior cranial fossa spontaneous CSF leaks to determine if they are randomly distributed or cluster in specific anatomic locations.

Objective

Our goal was to examine a cohort of spontaneous anterior cranial fossa CSF leaks and to create a map demonstrating their distribution within the anterior cranial fossa. We also aim to determine whether these leaks are randomly distributed or demonstrate an anatomic predilection for a specific site.

Methods

We performed a retrospective review of a prospectively acquired surgical database of all endonasal endoscopic cases performed at Weill Cornell Medical College by the senior authors. Spontaneous CSF fistulae of the anterior skull base were identified. The anatomic site of the defects were located on radiographic imaging and normalized to a theoretical 4x2 grid representing the anterior midline skull base. Data from the left and right skull base were combined to increase statistical power. This grid was then used to analyze the distribution of defects. Frequency analysis using the Chi-square test was performed, with a subsequent Monte Carlo simulation to further strengthen statistical support of conclusions.

Results

We identified 19 cases. Mean age was 42 years (Range 16-66y), average BMI 30.4 (Range 21.4-39; n=14) and 79% were female. Frequency analysis using the Chi-square test indicated a non-random distribution of sites (p = 0.035). We also performed a Monte Carlo simulation in which 5000 random permutations of stochastically distributed leakage sites were compared with the actual data. This yielded a p-value of 0.034, further confirming a non-random distribution of sites. 74% of cases occurred in the cribiform plate (p=0.086). Moreover, 37% of all defects occurred in the posterior 1/3 of the cribiform plate.

Discussion

Spontaneous CSF leaks arise from a combination of a constant or recurrent increase in intracranial pressure (ICP) and a structural weakness of the skull base. This study demonstrates that these lesions are not randomly distributed within the anterior skull base, but tend to cluster within the area of the posterior cribiform plate.

A possible explanation is that the cribiform plate is widest in its posterior aspect. Hence the area in which defects may form is comparatively larger and thus the incidence of leaks in this region is higher. Moreover the anterior cribiform plate is strongly buttressed by the thick bone of the crista galli. Given the thinness of the bone and its multiple perforations from the olfactory filia, the lack of lateral buttressing and the increased surface area in the posterior cribiform plate, this creates a point of maximum weakness and highest predisposition to CSF fistula in the face of chronically increased ICP.

Limitations to this study include the retrospective nature of the study, anatomic warping due to bony remodeling, spatial overrepresentation due to the normalization process and relatively small sample size.

Conclusions

Anterior skull base spontaneous CSF leaks are distributed in a non-random fashion. The most likely site of origin of spontaneous CSF leaks of the anterior midline skull base is the cribiform plate, particularly the posterior 1/3 of the plate, likely because of a lack of significant thick bony buttressing. Clinicians searching for occult spontaneous leaks of the anterior skull base should examine the posterior 1/3 with particularly close scrutiny.

References