



Hemorrhagic and Non-hemorrhagic Pituitary Apoplexy: Clinical Analysis

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Authors' contributions

This work was carried out in collaboration between all authors. Authors KOR and TBV designed the study and wrote the protocol. Author DMP wrote the first draft of the manuscript and managed the literature searches. Authors JHM, SS, ED, DMP and DEM performed data collection. Author JHM performed statistical analyses. Authors NBO and KOR made revisions to the manuscript. Authors KOR and TBV managed the experimental process. All authors read and approved the final manuscript.

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ABSTRACT

Objective: The diagnosis of hemorrhagic versus non-hemorrhagic pituitary apoplexy can be difficult as both the clinical presentation and radiographic appearance can be variable. Early identification and treatment of these patients is essential to prevent poor outcomes. This study identifies clinical characteristics of hemorrhagic and non-hemorrhagic pituitary apoplexy.

Methods: 311 consecutive patients admitted with pituitary tumors were reviewed for clinical and radiographic evidence of pituitary apoplexy. Patient demographics, comorbidities, clinical presentation, tumor characteristics, surgical therapy, complications, and outcomes were analyzed

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for both groups. A cohort statistical analysis was performed using Chi square, Fisher exact test, and t-test.

Results: Patients with hemorrhagic (n = 23, 57.5%) and non-hemorrhagic (n=17, 42.5%) pituitary apoplexy were similar except the hemorrhagic cohort was older (mean age 51.5 versus 40.6, p=0.03) and more hypertensive (n=16, p=0.03). Thirty-seven patients underwent surgical decompression for their pituitary apoplexy symptoms either through transcranial or endoscopic approach. There was no statistically significant difference between hemorrhagic (n=16, 43.2% endoscopic; n=4, 10.8% transcranial) and non-hemorrhagic (n=16, 43.2%, endoscopic; n=1, 2.7%, transcranial; p=0.22) apoplexy cohorts. Risks of post-operative complications were similar in both hemorrhagic (n=5: RR 1.13, 95% CI 0.59-2.1) and non-hemorrhagic cohorts (n=3: RR 0.84, 95% CI 0.31-2.3). Achievement of a good functional outcome as measured by modified Rankin scale better than 4 at last follow-up was not statistically different among cohorts (p = 0.74).

Conclusions: Hemorrhagic and non-hemorrhagic pituitary apoplexy are similar clinical entities that require prompt surgical decompression of the optic apparatus and medical therapy aimed at treating acute adrenal insufficiency.

Keywords: Apoplexy; pituitary; endocrine; hemorrhage.

1. INTRODUCTION

First described in 1898 by the American neurologist P. Bailey, pituitary apoplexy represents an emergent neurosurgical condition involving hemorrhagic or non-hemorrhagic infarction of the pituitary gland in the setting of underlying cystic pathology or a macroadenoma, or less commonly in a non-diseased pituitary gland, that may result in rapid intrasellar and extrasellar expansion causing mass effect on surrounding structures, meningismus from cisternal extension of hemorrhage, and pituitary failure [1,2]. It has been estimated to occur in up to 0.6-12.3% of patients with pituitary adenomas (although the incidence of non-apoplectic bleeds may be greater). Approximately 80% of patients with apoplexy have undiagnosed pituitary tumors [2-4]. Undiagnosed, pituitary apoplexy is associated with significant morbidity and mortality and may lead to devastating neurologic and endocrinologic consequences. The early recognition of this condition is essential to timely surgical decompression and institution of appropriate medical therapy to avoid permanent sequelae. Barriers to timely detection include delayed presentation or failure of the condition to generate heightened clinical concern due to non-specific symptoms or radiographic findings; for instance, non-hemorrhagic pituitary apoplexy often symptomatically mimics an in situ pituitary adenoma and may present sub-clinically.

A number of patient factors and clinical manifestations of pituitary apoplexy have been described in the literature as being useful predictors of the condition [5,6]. Common yet non-specific symptoms include headache,

nausea, vomiting, visual disturbances, cranial nerve palsies, altered mental status, and meningismus. These symptoms in a patient with a history of a pituitary lesion or in conjunction with signs of hypopituitarism are more concerning for pituitary apoplexy. Given the emergent nature of pituitary apoplexy and its potentially irreversible consequences, it is important to identify well-defined clinical harbingers in the history and physical to aid in efficient and timely diagnosis of the condition. This is particularly important given that these patients will most often undergo initial evaluation by a physician without advanced radiological or neurosurgical expertise.

A number of studies have been published offering varying data with regards to the predictive significance of specific patient factors such as demographics, medical comorbidities, social habits, medication use, and specific type of pre-existing pituitary pathology [7-10]. However, there have been no studies to date that have specifically focused on the distinction between the hemorrhagic and non-hemorrhagic subtypes of pituitary apoplexy based on clinical characteristics. Our study aims to identify the clinical features that correlate with pathologic findings in patients with either hemorrhagic or non-hemorrhagic pituitary apoplexy, to determine whether they differ significantly based on the type of apoplexy, and to examine the complications and outcomes of treatment. These findings will add to the existing body of knowledge on the subject and provide physicians with additional tools for establishing an accurate diagnosis to optimize patient care.

2. MATERIALS AND METHODS

A total of three hundred eleven subjects consecutively admitted to a single institution with a diagnosis of pituitary tumor from January 2006 to February 2013 were included for initial analysis. The Institutional Review Board of the University of Alabama at Birmingham provided approval prior to the conduct of this study. A retrospective cohort review of clinical and radiographic findings in patients diagnosed with a known pituitary tumor was performed to identify apoplexy. The records of apoplexy patients were present in the electronic medical record.

Forty patients were identified for inclusion in this study. The determination of hemorrhagic apoplexy was based on radiographic assessment, intraoperative findings, and pathology demonstrating frank hemorrhage within a pituitary adenoma. The finding of non-hemorrhagic apoplexy was established through non-hemorrhagic characteristics on imaging and lack of hemorrhagic diagnosis. The researchers involved in the study include both neurosurgery and endocrinology staff and residents, qualified to assess brain imaging, as well as review intraoperative notes and clinical records.

Medical records for each of the forty subjects were reviewed further in detail for clinical characteristics. A retrospective cohort review of clinical and radiographic findings in patients diagnosed with a known pituitary tumor who presented with pituitary apoplexy was conducted. Patient demographics, comorbidities, initial clinical presentation, pituitary hormones, and tumor characteristics were collected and analyzed for both hemorrhagic and non-hemorrhagic apoplexy groups. The radiological finding of sellar hyperdensity and their Hounsfield units on computed tomography, as well as hyperintensity on magnetic resonance imaging

were identified as hemorrhagic apoplexy and the absence of these characteristics considered as non-hemorrhagic apoplexy.

Additionally, thirty-seven of these patients underwent surgical decompression for their pituitary apoplexy symptoms. The post-operative complications and outcomes in terms of pituitary deficiencies, visual changes, functional status, and length of stay as well as surgical approach were reviewed and compared between hemorrhagic and non-hemorrhagic apoplexy patients.

A cohort statistical analysis was performed comparing hemorrhagic versus non-hemorrhagic apoplexy using Chi Square, Fisher exact test, logistic regression, ANOVA, and t-test.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Demographics

Out of the three hundred eleven subjects consecutively admitted with a diagnosis of pituitary tumor, forty patients (13%) were classified as having apoplexy and included for initial analysis. 23 patients were identified to have hemorrhagic and 17 patients were found to have non-hemorrhagic apoplexy (Table 1). Average age was 51.5±15.8 (mean +/- standard deviation) for patients with hemorrhagic pituitary apoplexy and 40.6±13.7 (mean +/- standard deviation) for patients with non-hemorrhagic pituitary apoplexy. Among the hemorrhagic cohort (n=23), there were 13 (32.5%) males and 10 (25%) females, 10 (25%) Whites, 12 (30%) Blacks, and 1 (2.5%) Hispanic. Among the non-hemorrhagic cohort (n=17), there were 10 (25%) males and 7 (17.6%) females, 8 (20%) Whites, 8 (20%) Blacks, and 1 (2.5%) Hispanic.

Table 1. Demographic information for 40 patients with hemorrhagic or non-hemorrhagic pituitary apoplexy

	Total (n=40)	Hemorrhagic (n=23)	Non-hemorrhagic (n=17)	p value
Age, mean ± SD	46.05±14.75	51.5±15.8	40.6±13.7	0.03
Sex, n (%)				0.8
Male	23 (57.5)	13 (32.5)	10 (25)	
Female	17 (42.5)	10 (25)	7 (17.6)	
Race, n (%)				0.43
White	18 (45)	10 (25)	8 (20)	
Black	20 (50)	12 (30)	8 (20)	
Hispanic	2 (5)	1 (2.5)	1 (2.5)	

Patients with hemorrhagic (n = 23, 57.5%) and non-hemorrhagic (n=17, 42.5%) pituitary apoplexy were similar except the hemorrhagic cohort was older (mean age 51.5 versus 40.6, p=0.03) (Table 1). No statistically significant differences were found between the cohorts with regard to gender (p=0.8) or race (p=0.43).

3.1.2 Comorbidities

Average body mass index (BMI) was 33.5±12.7 (mean +/- standard deviation) for patients with hemorrhagic pituitary apoplexy and 33.3±11.1 (mean +/- standard deviation) for patients with non-hemorrhagic pituitary apoplexy (Table 2). Among the hemorrhagic cohort (n=23), 16 (40%) had a prior diagnosis of essential hypertension, 6 (15%) had diabetes, 6 (15%) had a history of smoking, and 2 (5%) were peripartum. Among the non-hemorrhagic cohort (n=17), 6 (15%) had a prior diagnosis of essential hypertension, 4 (10%) had diabetes, 5 (12.8%) had a history of smoking, and 1 (2.5%) was peripartum.

Patients with hemorrhagic (n = 23, 57.5%) and non-hemorrhagic (n=17, 42.5%) pituitary apoplexy were similar except the hemorrhagic cohort was more hypertensive (n=16 versus n=6, p=0.03). No statistically significant differences were found between the cohorts with regard to diabetes (p=0.8), smoking status (p=0.9), peripartum state (p=0.7), or the anti-platelet medication, Aspirin (p=0.2). No patients were on anticoagulant medications (Coumadin, Xarelto, Eliquis) or other anti-platelet agents (Plavix, Ticlid, Aggrenox).

3.1.3 Clinical presentation

Among patients with hemorrhagic pituitary apoplexy (n=23), 22 (56%) had an initial presentation that included headache, 20 (52.6%) had visual complaints, 7 (20%) had poor vision ≥ (20/200), 9 (22.5%) had cranial nerve palsies,

and 2 (5%) had altered mental status (Table 3). Among patients with non-hemorrhagic pituitary apoplexy (n=17), 16 (41%) had headache, 16 (42.1%) had visual complaints, 9 (25.7%) had poor vision ≥ (20/200), 10 (25%) had cranial nerve palsies, and 0 (0%) had altered mental status.

Patients with hemorrhagic (n = 23, 57.5%) and non-hemorrhagic (n=17, 42.5%) pituitary apoplexy were similar with regard to presenting symptoms, with no statistically significant differences between the cohorts for any symptom.

3.1.4 Tumor characteristics

Among patients with hemorrhagic pituitary apoplexy (n=23), the pre-existing adenoma was found to be non-functioning in 19 (47.5%), prolactin-secreting in 1 (2.5%), and GH-secreting in 3 (7.5%) (Table 4). Among patients with non-hemorrhagic pituitary apoplexy (n=17), 12 (30%) had non-functioning adenomas, 4 (10%) had prolactin-secreting adenomas, none had GH-secreting adenomas, and 1 (2.5%) had unknown functional status. There was no statistically significant difference between the two cohorts with regard to adenoma type (p=0.08). There were no tumors with atypical morphology.

3.1.5 Postoperative outcomes

Thirty-seven patients underwent surgical decompression for their pituitary apoplexy symptoms. 17 (45.9%) hemorrhagic and 16 (43.2%) non-hemorrhagic apoplexy patients underwent endoscopic procedure, while 4 (10.8%) hemorrhagic and 1 (2.7%) non-hemorrhagic apoplexy patients were treated with open or transcranial surgical technique (Table 5). There were no statistically significant differences in the surgical therapy between the two cohorts (p=0.22).

Table 2. Medical comorbidities among 40 patients with hemorrhagic or non-hemorrhagic pituitary apoplexy

	Total (n=40)	Hemorrhagic (n=23)	Non-hemorrhagic (n=17)	p value
Essential hypertension, n (%)	22 (55)	16 (40)	6 (15)	0.03
Diabetes, n (%)	10 (25)	6 (15)	4 (10)	0.8
Smoking, n (%)	11 (27.5)	6 (15)	5 (12.8)	0.9
Peripartum, n (%)	3 (7.5)	2 (5)	1 (2.5)	0.7
BMI, mean ± SD	33.4±12.2	33.5±12.7	33.3±11.1	0.9
Anti-platelet (Aspirin)	3 (7.5)	1 (0.025)	2 (0.05)	0.2

Table 3. Presenting symptoms for 40 patients with hemorrhagic or non-hemorrhagic pituitary apoplexy

	Total (n=40)	Hemorrhagic (n=23)	Non-hemorrhagic (n=17)	p value
Headache	38 (95)	22 (56)	16 (41)	0.2
Visual complaints	36 (90)	20 (52.6)	16 (42.1)	0.8
Poor vision \geq (20/200)	16 (40)	7 (20)	9 (25.7)	0.4
Cranial nerve palsy	19 (47.5)	9 (22.5)	10 (25)	0.2
Altered mental status	2 (5)	2 (5)	0 (0)	0.13

Table 4. Tumor characteristics for 40 patients with hemorrhagic or non-hemorrhagic pituitary apoplexy

	Total (n=40)	Hemorrhagic (n=23)	Non-hemorrhagic (n=17)	p value
Adenoma type				0.08
Non-functioning	31 (77.5)	19 (47.5)	12 (30)	
Prolactin secreting	5 (12.5)	1 (2.5)	4 (10)	
GH secreting	3 (7.5)	3 (7.5)	0 (0)	
Unknown	1 (2.5)	0 (0)	1 (2.5)	

Table 5. Surgical treatment: Endoscopic versus transcranial (n=37)

	Hemorrhagic	Non-hemorrhagic	p-value
Endoscopic	17 (45.9%)	16 (43.2%)	0.22
Transcranial (open)	4 (10.8%)	1 (2.7%)	0.23

Risks of post-operative complications were similar in both hemorrhagic (n=5: RR 1.13, 95% CI 0.59-2.1) and non-hemorrhagic cohorts (n=3: RR 0.84, 95% CI 0.31-2.3) (Table 6). The complications included are CSF leak, epistaxis, meningitis, and visual decline. Achievement of a good functional outcome as measured by modified Rankin scale better than 4 at last follow-up was not statistically different among hemorrhagic (n=20, 54%) and non-hemorrhagic (n=14, 40.5%, p= 0.74) cohorts (Table 7). Furthermore, patients with post-apoplexy pituitary dysfunction were similar in both groups. The endocrine dysfunction in terms of one or more hormone deficiency was similar in the hemorrhagic (n =18, 48.7%) and non-

hemorrhagic (n = 12, 32.4%: p = 0.41) cohorts. Additionally, permanent DI was also similar in the hemorrhagic (n =7, 19%) and non-hemorrhagic (n = 3, 9%: p = 0.35) groups. More importantly, no patient's vision worsened following surgery and 70.2% had improved visual acuity at discharge or last follow-up. There was no statically significant difference between hemorrhagic (n=15, 40.5%) and non-hemorrhagic (n=11, 29.7%, p=0.66) cohorts. Average length of stay was 3.3 +/- 1.1 days (mean \pm standard deviation). There was no statistically significant difference between hemorrhagic and non-hemorrhagic apoplexy patients' length of stay (p=0.12).

Table 6. Complications (n=37)

	Hemorrhagic	Non-hemorrhagic	p-value
Relative risk	1.13	0.84	
95% Confidence interval	0.59-2.10	0.31 -2.30	
n (%)	5 (13.5%)	3 (8.1%)	0.73

Table 7. Post surgical outcomes (n=37)

	Hemorrhagic	Non-hemorrhagic	p-value
Good functional outcome (mRS <4)	20 (54%)	15 (40.5%)	0.74
Endocrine dysfunction	18 (48.7%)	12 (32.4%)	0.41
Permanent DI	7 (19%)	3 (9%)	0.35
Visual improvement	15 (40.5%)	11 (29.7%)	0.66

3.2 Discussion

Up to date, no study exists comparing the clinical features of hemorrhagic and non-hemorrhagic pituitary apoplexy. The present investigation is the first to shed light on the clinical predictors of apoplexy, tumor pathology, and surgical therapy and outcomes between hemorrhagic and non-hemorrhagic pituitary apoplexy.

3.2.1 Clinical predictors of apoplexy

The present study identified pituitary apoplexy in approximately 13% of patients admitted with pituitary adenomas. The difficulty in estimating the overall incidence of this condition is at least in part due to the lack of comprehensive population-based studies regarding apoplexy in patients with pituitary adenomas [11]. Other studies have identified rates as low as 0.6% to upwards of 16.6%, a range with which our data was consistent [3,4].

The data from the present study did not reveal any ubiquitous demographic or comorbidity among patients with pituitary apoplexy. The most commonly observed comorbidity was essential hypertension (n=22, 55%), and patients tended to be obese as evidenced by the average body mass index >30 kg/m². The results do suggest that the patient characteristics of increased age and essential hypertension occur at a statistically greater frequency in patients with hemorrhagic pituitary apoplexy than those with non-hemorrhagic apoplexy. Gender, race, smoking, diabetes, body mass index, peripartum state, and use of anti-platelet and anticoagulation agents did not differ significantly between the two cohorts.

The pathophysiology of the hemorrhagic versus non-hemorrhagic apoplexy is incompletely understood. Theories of hemorrhagic pathophysiology could include the presence of vasculopathy or abnormal blood vessels with incomplete maturation, poor fenestration, and thin basal membrane that may be susceptible to rupture [12,13]. It is probable that advanced age and essential hypertension exacerbate the vasculopathy and cause hemorrhage. Non-hemorrhagic apoplexy could be due to pituitary tumors simply outgrowing their blood supply or compression of the superior hypophyseal artery against the diaphragm sella by the upward growing mass and this could potentially lead to ischemic necrosis of the tumor [14].

Previous studies have considered the associations among patient factors and pituitary

apoplexy. In a 1981 case series, Wakai et al. [10] found no statistical correlation between hemorrhagic pituitary apoplexy and gender but did find a significant positive association with age. Other studies have failed to identify significant correlations between pituitary apoplexy and essential hypertension or diabetes [8,15]. Anticoagulation and pro-thrombotic states have been implicated as risk factors for pituitary apoplexy in the same way they would be for any cerebrovascular accident [15,16]. A number of cases have been described that suggest an association between pituitary apoplexy and the use of dopamine agonists such as bromocriptine or cabergoline in the treatment of prolactinomas [7,17,18]. It is thought that dopamine agonists induce necrotic changes in tumor cells, and the resulting shrinkage and involution that occurs with replacement fibrosis predisposes to bleeding [17]. Socioeconomic factors have been suggested to play a role in determining the risk for pituitary apoplexy, with increased risk among individuals with less access to healthcare and less social support [9].

Headache and visual complaints were present in the majority of apoplexy patients in this study (n=38, 95% and n=36, 90% respectively) and did not significantly differ between the hemorrhagic and non-hemorrhagic groups. Poor vision and cranial nerve palsies (n=16, 40% and n=19, 47.5% respectively) were less common and altered mental status was rare (n=2, 5%); again, the incidence of these symptoms did not differ significantly between the hemorrhagic and non-hemorrhagic groups. Other studies have also shown headache and visual complaints, particularly those related to diplopia and ophthalmoplegia, to be among the most common presenting symptoms of pituitary apoplexy [15,19,20]. Nausea, vomiting, meningismus, visual field defects, hemiparesis, hypopituitarism, galactorrhea, and amenorrhea have also been described in the literature as symptoms and observations made at the time of presentation with pituitary apoplexy [10,15,19,20]. As mentioned earlier, while many of these symptoms can be non-specific, acuity of onset and either a prior diagnosis of a pituitary adenoma or evidence of pituitary insufficiency should heighten the clinical concern for pituitary apoplexy.

In this study, the number of patients presenting with hemorrhagic and non-hemorrhagic apoplexy was 54% and 46% respectively. Although not considered the traditional underlying pathophysiology in pituitary apoplexy, the non-

hemorrhagic apoplexy represented a big group of the patient population seen at our institution. This underscores the critical importance of recognizing not only hemorrhagic apoplexy, but also non-hemorrhagic patients when clinically evaluating for possible apoplexy.

3.2.2 Tumor pathology

In terms of the characteristics of pre-existing pituitary adenomas, the results of this study showed a predominance of non-functioning adenomas (n=31, 77.5%) as opposed to prolactin-secreting (n=5, 12.5%), GH-secreting (n=3, 7.5%), or unknown status (n=1, 2.5%). Other studies have also found a greater incidence of pituitary apoplexy among non-functioning adenomas [15,19]. Interestingly, the aforementioned case series by Wakai et. al. did not find adenoma histopathology or secretory status to be statistically significant predictors of pituitary apoplexy [10]. In the present study, the secretory status did not differ significantly between the hemorrhagic and non-hemorrhagic apoplexy cohorts. Size has also been implicated as an important predictor of risk for pituitary apoplexy, with macroadenomas being more likely to bleed than microadenomas [8,15]. Proposed mechanisms for the size relationship include vascular insufficiency of larger tumors, compression of the hypophyseal vessels, and increased friability of vasculature [4,21–23].

3.2.3 Surgical therapy and outcomes

Although no statistically significant differences in the surgical therapy between the two cohorts exist in this study, majority of apoplexy patients (n=33, 89.1%) underwent endoscopic decompression. Very few apoplexy patients (n=5, 13.5%) were treated with open surgery. These findings reflect the current preferred method for pituitary surgery as transsphenoidal decompression—a standard therapy providing more protection for the optic nerves and chiasm, allowing completeness of tumor removal, and preventing possible complications such as cerebrospinal fluid (CSF) leakage, meningitis, and tension pneumocephalus [24,25].

The present study found a lack of statistically significant differences between the hemorrhagic and non-hemorrhagic cohorts in terms of post-operative complications and outcomes, specifically relative risks of complications, mRS or likelihood of a good functional outcome (mRS>4), length of hospitalization, endocrine

dysfunction, permanent DI, and improvement in visual acuity.

The risks of post-operative complications were similar in both hemorrhagic (1.13%) and non-hemorrhagic cohorts (0.84%). Similarly, Ciric et al report 1-2% of incidence of complications post transsphenoidal decompression, which is the surgical approach used in the majority of the patients reported in this series [26]. Furthermore, good functional outcome was measured by modified Rankin scale better than 4 at last follow-up in 54.0% hemorrhagic and 40.5% non-hemorrhagic, overall 94.6% patients. Although no report exists documenting outcomes in terms of modified ranking scale for post-operative apoplexy patients, endoscopic surgery's overall very low mortality (less than 0.5%) and morbidity (1-2%) [27] supports our findings of good functional outcome in 91.8% of patients in this study. Additionally, approximately 3.3 +/- 1.1 days of hospitalization supports previous reported range of 3.6 days of hospital stay [28] for minimally invasive pituitary surgery.

This study's results show low percentage of apoplexy patients with permanent DI post operatively, ranging from 9% in hemorrhagic and 19% in non-hemorrhagic cohort. It has been shown that the hypopituitarism associated with pituitary apoplexy is often rapidly reversed following surgical decompression, thus yielding good endocrinologic outcomes as well [29]. Additionally, endocrine dysfunction in terms of one or more hormone deficiency was similar in the hemorrhagic and non-hemorrhagic cohorts, 48.7% and 32.4%, respectively. Although no prior studies compare hemorrhagic with non-hemorrhagic apoplexy subgroups, long term steroid and other hormone replacement post-surgery has been documented in the range of 45-58% [6], which encompasses this study's findings.

No patient's vision worsened following surgery and 70.2% had improved visual acuity at discharge or last follow-up. Other studies have also demonstrated favorable visual outcomes following surgical decompression of pituitary apoplexy; however, variations in visual parameters and lack of standardized measures of improvement have made it difficult to compare the results of these studies [30].

3.2.4 Limitations

Limitations of this study include its retrospective design, small sample size, and lack of a control

group. Due to the disease entity of study, it is not very feasible to escape retrospective analysis for initial investigation to characterize pathology, more specifically hemorrhagic versus non-hemorrhagic pituitary apoplexy. The small sample size limitation is difficult to overcome given the low prevalence of pituitary apoplexy. More importantly, the number of patients in this study was comparable to sample sizes in other published literature on the related subjects. Inclusion of a control group of patients with pituitary adenomas and no evidence pituitary apoplexy would have allowed a determination to be made regarding whether the different clinical features analyzed in this study have a statistical predilection to pituitary apoplexy and its subtypes. It was not the authors' intention to replicate the results of prior studies by identifying the clinical factors associated with pituitary apoplexy. Instead, the authors sought to answer the question of whether clinical predictors of apoplexy would vary between the hemorrhagic and non-hemorrhagic subtypes. That being said, future studies would benefit from an analysis of whether certain clinical features are statistically significant predictors of one or both subtypes of pituitary apoplexy. Nevertheless, the findings of this study are comprehensive in the analysis of the other predictors of apoplexy and warrant reporting.

4. CONCLUSION

This study is the first to analyze the differences between the clinical features of hemorrhagic and non-hemorrhagic pituitary apoplexy, demonstrating that they are similar clinical entities with hemorrhagic apoplexy patients being on average older and more likely to be hypertensive. The data re-iterate the potential for favorable neurologic and endocrinological outcomes with prompt surgical decompression of the optic apparatus and medical therapy aimed at treating acute adrenal insufficiency.

CONSENT

It is not applicable to this study.

ETHICAL APPROVAL

The Institutional Review Board of the University of Alabama at Birmingham provided approval prior to the conduct of this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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