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Clinical and neuroradiological red flags in differential diagnosis of pituitary metastases and PitNETs (adenomas): a surgeon's experience and systematic literature review

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ABSTRACT

Introduction. Pituitary metastases (PMs) are rare malignancy manifestations, generally deemed to have an extremely poor prognosis. Differential diagnosis from primary pituitary lesions is often difficult, as their features can mimic those of pituitary neuroendocrine tumours (PitNETs). This study aimed to report a single surgeon's experience in managing PMs and to gather the existing evidence on their clinical and neuroradiological presentation to build a model of 'red flags' that help raise the suspicion of PMs in the context of sellar lesions.

Material and methods. We retrieved an original 10-year surgical series of patients undergoing endoscopic transsphenoidal (TNS) surgery for suspected PitNETs, and we additionally conducted a systematic review of case reports or series of patients with PMs.

Results. The local series consisted of n = 6 PMs. The literature review yielded n = 149 works reporting n = 340 PMs. Overall, the clinical presentation and neuroradiological features of n = 346 PMs were analysed and compared to data retrieved from n = 361 PitNETs from our original cohort. Primary features associated with PMs were: the presence of headaches (OR 1.24, p = 0.001), visual field deficits (OR 1.19, p = 0.02), extraocular nerve palsies (OR 1.23, p = 0.001), diabetes insipidus (OR 2.13, p < 0.001), MRI features of pituitary stalk/infundibular involvement (OR 1.98, p = 0.001), cavernous sinus invasion (OR 1.57, p = 0.004), and T2w flow voids (OR 1.13, p = 0.001). An incidental diagnosis (OR 0.49, p < 0.001) and cystic changes (OR 0.77, p = 0.02) were less common among PMs. Secondary features involved an acute onset of symptoms (OR 1.25, p = 0.001), the presence of oncological history (OR 1.89, p = 0.001), sellar walls erosion (OR 1.55, p = 0.002), and gross appearance of a firm (OR 2.01, p < 0.001) and easily bleeding lesion (OR 1.99, p < 0.001). Sellar enlargement predicted a lower risk of PMs (OR 0.54, p = 0.001).

Conclusion. We have compiled a list of primary and secondary red flags, including clinical and neuroradiological features, to serve as a guiding tool for clinicians to raise suspicion of PMs and aid in the differential diagnosis of various lesions centered in the sella.

Keywords: pituitary metastases, sellar lesions, clinical red flags

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Introduction

Pituitary metastases (PMs) are a rare manifestation of malignancy, comprising only about 0.4% of all intracranial localisations [1], whereas pituitary neuroendocrine tumours (PitNETs) account for about 15% of all primary intracranial neoplasms [2]. Breast and lung tumours comprise more than half of all reported cases of PMs [1]. However, other histological subtypes, including renal, thyroid, gastrointestinal, hepatic (HCC), and prostate cancer, can contribute to a significant number of PMs. The most substantial anatomical basis for PM seeding includes the location of the pituitary fossa and gland outside the blood-brain barrier, with the stalk and posterior pituitary gland particularly susceptible to metastatic spread due to vascular reasons [1].

From a diagnostic perspective, distinguishing PMs from primary PitNETs is often challenging because their clinical and neuro-radiological features are usually nonspecific [3]. Nonetheless, advances in imaging technology, increased sensitivity of endocrine testing, and improved survival of oncological patients with systemic disease all facilitate earlier detection.

Prognosis among patients with PM is generally poor, with reported median survival of as little as 4–13 months, depending on the underlying malignancy [1, 4–6]. Pituitary localisation is often associated with significant endocrinological disturbances that can have a significant impact on quality of life and patients' fitness to withstand surgery and adjuvant chemo/radiotherapeutic strategies [2, 6]. However, with advances in surgery and stereotactic radiosurgery, the landscape for diagnosing and managing PMs has undergone a dramatic evolution. Patient series consistently demonstrate an overall improvement in oncological outcomes.

Herein, we report a retrospective analysis of an original series, along with a systematic review of PM cases, to define clinical and neuro-radiological presentation patterns. These have been grouped into a list of red flags that should raise suspicion of PMs in the context of sellar lesions.

Material and methods

Original series

Study design, patient selection, and data retrieval

We retrospectively screened a 10-year (2012–2022) local series of patients treated for suspected PitNETs by the senior author of this paper. Demographic data, as well as pre-operative symptoms, oncological history, tumour extension, the extent of tumour resection, histology, post-operative treatments (radiotherapy and/or chemotherapy), tumour recurrence, and complications, were retrospectively collected from medical records, intra-operative videos, and imaging.

Diagnostic work-up and follow-up

All patients underwent preoperative and postoperative 1.5 T magnetic resonance imaging (MRI) scans, as well as pre- and postoperative neuro-ophthalmological assessments. Blood tests for pituitary function included measurements of ACTH, cortisol, TSH, free T3 (fT3), free T4 (fT4), hGH, testosterone, LH, FSH, and prolactin (PRL).

Tumoral volumes were segmented on preoperative MRI imaging using Cranial Planning Anatomical Mapping (version 1.1.1.8) and SmartBrush (version 3.0.0.92) (Brainlab AG) with axial, sagittal, and coronal cuts on T1-weighted (T1w) pre- and post-gadolinium contrast-enhancing (CE) and T2-weighted (T2w) sequences. An additional CT scan was performed in selected cases for surgical planning purposes or in emergency settings. MRI and CT features were double-assessed by two independent neurosurgeons. Sellar erosion and enlargement were assessed at MRI and confirmed at CT scan.

Follow-up was performed within the first week and again six weeks after surgery, followed by subsequent visits based on individual hormonal and MRI findings. Patients diagnosed with PM were referred to the Oncology team to receive adjuvant treatments and specialist follow-up according to their underlying condition.

Surgical approach and extent of resection (EOR)

All included cases were assessed by a multidisciplinary team comprising neurosurgeons, neuro-oncologists, pathologists, and neuro-radiologists. Surgical indication was confirmed, and endoscopic endonasal transsphenoidal approach (TNS) was the treatment of choice in all cases. All procedures were documented and then retrospectively analysed to retrieve intra-operative lesional features and complications. Specimens were routinely sent for neuropathological analysis.

Gross total resection (GTR) was defined as complete tumour removal as determined by a postoperative MRI scan. Near total resection (NTR) was defined as > 90% tumour resection. Subtotal resection (STR) was defined as < 90% but more than 35% tumour resection.

Systematic review of literature

We performed a systematic review of available literature in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement [7] to identify single case reports or case series of PMs using a strategic combination of key words i.e. 'pituitary', 'sellar', 'metastases', and 'metastatic tumour'. This study was not prospectively registered.

International databases (MEDLINE via PubMed, ScienceDirect, and Embase) were searched up to and including June 2024 to identify pertinent papers using EndNote X9.2 (Clarivate, Philadelphia, PA, USA). References obtained from databases and literature were first independently examined at the title/abstract level. In cases of doubt or disagreement, full articles were retrieved, and the eligibility of a particular record was defined through discussion with a different reviewer.

Papers reporting other topics (e.g., other sellar lesions), studies reporting narrative review articles, meta-analyses, and any papers not reporting patient-level data were excluded.

Only patients with a confirmed diagnosis of PMs and with available clinical or neuroradiological presenting characteristics were included. We only included articles written in English. No time restrictions were enforced.

Data was manually extracted using standardised forms. All data was retrieved following an already-defined PICO strategy. The supplementary material outlines more details on the data retrieval and extraction strategy.

Statistical analysis

Statistical analysis was conducted using R Core Team (2022). Categorical variables were reported as absolute numbers and percentages, whereas continuous variables were reported as mean and standard deviation or median and range. Systematic review data were analysed at the single-patient level.

The difference in baseline clinical characteristics and the unadjusted univariate analyses were performed using a t-test or Mann–Whitney U-test in accordance with the normality of the distribution, and a Chi-square or Fisher's exact test, where appropriate. Firstly, we compared the PMs to PitNETs within our original series. This is referred to as the 'local set'. The same comparison was repeated between all PMs (original series + + systematic review) and PitNETs from the original series. This is referred to as the 'systematic set'). The results of all tests were presented as p-values, and statistical significance was set at a probability value of 0.05 (95% confidence interval).

A panel of red flags for PMs was constructed based on regression analysis data. Not all variables tested in the local set could be retrieved in published works. Therefore, only a subgroup of variables could be validated in the systematic set. Baseline variables validated in the systematic set were defined as 'primary features', while variables only tested in the local set were presented as 'secondary features'. Since these features were only tested against a local series of PitNETs, we could not perform a formal meta-analysis of data to infer the reciprocal influence of these parameters and their contribution to the model's predictive value. For this reason, our proposed red flags model only presents a list of parameters, without any additional scoring information.

Results

Original series

All included patients and lesions

We retrieved 386 patients with sellar lesions at our institution. Lesions with no histological report of non-diagnostic specimens (n = 19) were excluded. Three hundred sixty-seven patients were included in the final analysis. The mean age at presentation was 50.2 ± 9.8 years, with 159 females and 208 males. Patients shared a median 100 (range 80–100) Karnofsky performance status score (KPS), and there was a known underlying oncological condition in n = 28 cases (8%).

All included patients underwent surgical resection via TNS. Most were in the elective setting (n = 345, 94%), while in 22 cases (6%), emergency surgery was warranted to relieve acute-onset neurological deficits. Pathology confirmed the diagnosis of PitNETs in n = 361 (98%) cases and PMs in n = 6 (2%). Among PitNETs, non-clinically functioning (NF-PitNETs) were the most frequent (n = 155, 42%), followed by prolactinomas (n = 144, 39%), GH-secreting (n = 40, 11%), and ACTH-secreting (n = 22, 6%). Intraoperatively, the lesions had a soft appearance in n = 336 (92%) cases, were firm in n = 31 (8%) cases, and bled easily in n = 16 (4%) cases.

A pituitary lesion was an incidental finding in n = 99 (27%). At the same time, the majority of the remaining patients presented with visual acuity deficits or field cuts (n = 152, 41%), headaches (n = 49, 13%), and extraocular muscle palsies (n = 46, 13%). Diabetes insipidus (DI) was present in n = 7 (2%) cases at presentation, while n = 146 (40%) patients demonstrated anterior pituitary deficits of at least one hormonal axis. In n = 63 (17%) cases, patients presented to medical attention within six months of symptom onset.

The mean lesional volume was 2.3 ± 1.4 cm^3, with most lesions (n = 195, 53%) presenting a maximal diameter > 1 cm and a suprasellar extension in n = 173 (47%). At MRI imaging, all included lesions presented some degree of contrast enhancement (CE). Cavernous sinus invasion was recorded in n = 60 (16%). Thickening or isolated pituitary stalk and infundibulum involvement was observed in n = 7 (2%). T2-weighted sequences revealed cystic transformation in n = 23 (6%) and flow-voids in n = 3 (1%). Sellar enlargement was detected in n = 201 (55%), while sellar erosion was detected in n = 46 (13%). See Table 1 for a comprehensive summary of baseline characteristics of all patients.

Pituitary metastases

Patients harbouring PMs were older than those with PitNETs (69.3 ± 7.7 vs. 45.3 ± 12.3 years, p = 0.02) and showed a 1:2 female-to-male ratio, not significantly different from PitNETs (p = 0.70). Table 2A compares PMs to PitNETs, whereas Table 3 describes the characteristics of PMs in our original cohort.

All PMs were synchronous to the primary tumour, and in three cases (numbers 1, 4, 5), pituitary symptoms were the harbinger of discovering the primary neoplasm. Patients had a previous oncological history in three of the remaining cases (50%). None of these PMs were found incidentally. Pathological examination revealed histological features of breast adenocarcinoma (n = 2), non-small cell lung carcinoma (NSCLC, n = 3), and papillary thyroid cancer (n = 1). Symptoms at presentation included visual acuity or field cuts in n = 5 (83%), headaches in n = 4 (67%), and oculomotor muscle palsies (VI cranial nerve) in n = 3 (50%). They had an acute onset (< 6 months) in n = 4 (67%). Signs and symptoms of anterior hypophysis dysfunction were a common presenting complaint (n = 4, 67%), being partial in n = 2, and involving all hormonal axes in the remaining two cases. Diabetes insipidus

Table 1. Original series of patients being treated for pituitary lesions

		All lesions (n = 367)
Demographics	Age (years)	50.2 ± 9.8
	Gender (F/M)	159/208
	Oncological history	28 (8%)
Performance	KPS	100 (80–100)
Surgery	Elective	345 (94%)
	Emergency	22 (6%)
Histology	PMs	6 (2%)
	NF-PitNETs	155 (42%)
	PRL-secreting	144 (39%)
	GH-secreting	40 (11%)
	ACTH-secreting	22 (6%)
Symptoms	Incidental finding	99 (27%)
	Visual field deficits	152 (41%)
	Headaches	49 (13%)
	Extraocular muscle palsy	46 (13%)
Hormonal	Diabetes insipidus	7 (2%)
	Hypopituitarism	146 (40%)
	Acute onset (< 6 months)	63 (17%)
Imaging	Max diameter > 1cm	195 (53%)
	Max diameter < 1cm	172 (47%)
	Mean volume [cm^3]	2.3 ± 1.4
	Suprasellar extension	173 (47%)
	T2 bright (cyst)	23 (6%)
	T2 voids	3 (1%)
	Cavernous sinus invasion	60 (16%)
	Stalk/infundibular involvement	7 (2%)
	Sellar enlargement	201 (55%)
	Sellar walls erosion	46 (13%)
Gross appearance	Soft	336 (92%)
	Firm	31 (8%)
	Easily bleeding	16 (4%)

Original series: baseline characteristics of patients treated for pituitary lesions. Data is presented as number (%) or mean ± standard deviation. KPS — Karnofsky Performance Status; NF-PitNETs — non-clinically functioning PitNETs

was diagnosed in n = 4 (67%) patients. Pre-operative hormonal levels in PM cases are shown in Table 4. Lesions had a mean volume of 5.7 ± 1.3 cm^3 and showed various degrees of CE, more often homogeneous (n = 4, 67%) rather than heterogeneous (n = 2, 33%). The cavernous sinus was invaded in n = 4 cases (67%), and the pituitary stalk was thickened with infundibular involvement in n = 2 (33%). In the n = 1 case (17%, ID #2), T2-w flow voids could be seen within the lesion. No cystic (bright T2w) changes or sellar enlargement could be seen in this cohort. Conversely, sellar walls and clivus erosion were detected in n = 4 (67%).

Following surgery, the headache subsided in all patients, and amelioration of visual symptoms was achieved in two cases (numbers 3 and 5), while the pre-operative oculomotor muscle palsies remained unchanged. Lesions were firm in n = 5 (83%) and easily bleeding in n = 4 (67%). Together with cavernous invasion and close relation with the visual pathways, these characteristics yielded STR in n = 4 (67%) and GTR in only n = 2 (33%). One patient (number 3) presenting a large lesion from NSCLC developed severe post-operative hypothalamic syndrome and died two weeks after surgery (see description of Illustrative Case). All the other patients underwent adjuvant therapies, including stereotactic radiotherapy (SRS-RT), chemotherapy, targeted therapies, and immunotherapies. The median overall survival (OS) was 8.5 months. Patients with breast adenocarcinoma (numbers 1 and 6) and patients with NSCLC (number 4) died of intracranial disease progression (diffuse central nervous system metastases). In contrast, the patient with papillar thyroid carcinoma and the other NSCLC case (numbers 2 and 5) experienced systemic disease progression. No other complications were detected, including postoperative bleeding, CSF leaks, pneumocephalus, or infection.

Pituitary metastases vs. PitNET (local set)

Compared to PMs, PitNETs overall presented as smaller lesions (2.3 ± 1.4 vs. 5.7 ± 1.3 cm^3) and were less commonly associated with an oncological history (n = 25, 7% vs. 50%; p = 0.007) and acute onset of symptoms (n = 59, 16%; p = 0.009), see Table 2A. They were slightly more often seen as incidental (n = 99, 27% vs. 0%; p = 0.19). Globally, PitNETs presented a reduced incidence of visual deficits (n = 147, 41% vs. 83%; p = 0.04), headaches (n = 45, 12% vs. 67%; p = 0.003), oculomotor muscle palsies (n = 43, 12% vs. 50%; p = 0.02), and DI (n = 3, 1% vs. 67%; p < 0.001), while the incidence of anterior hypophysis dysfunction did not significantly differ from PMs (n = 142, 39% vs. 67%; p = 0.22). PitNETs showed a similar suprasellar extension compared to PMs (n = 169, 47% vs. 67%, p = 0.42) but significantly less cavernous sinus invasion (n = 56, 16% vs. 67%; p < 0.001), stalk/infundibular involvement (n = 5, 1% vs. 33%; p < 0.001) and T2w flow voids (n = 2, 1% vs. 17%; p = 0.04). Cystic adenomas could be seen in n = 23 cases (6% vs. 0%; p = 1.00). Sellar enlargement was significantly more common in PitNETs n = 201 (56% vs. 0%; p = 0.008), whereas sellar wall erosions were rarer (n = 42, 12% vs. 67%; p = 0.003). Intraoperative recordings yielded the observation of PitNETs being less frequently firm (n = 5, 7% vs. 83%; p < 0.001) and with a lower tendency to bleed compared to PitNETs (n = 4, 3% vs. 67%; p < 0.001).

Regression analysis revealed a decisive predictive role for PMs of: the presence of oncological history (OR 1.89, 95% CI 1.39–2.30, p = 0.001), acute onset of symptoms (OR 1.25, 95% CI 1.11–1.75, p = 0.001), headache (OR 1.20, 95% CI 1.09–1.29, p = 0.001), visual deficits (OR 1.24, 95% CI 1.02–1.78, p = 0.03), extraocular muscle palsies (OR 1.12, 95% CI 1.05–1.26, p = 0.03), diabetes insipidus (OR 2.01,

Table 2. Univariate analysis of pituitary adenomas (PAs) vs. pituitary metastases (PMs) patients. Univariate analysis of baseline characteristics associated with PitNETs and PMs. (**2A**) Local set: comparison among patients from original series. (**2B**) Systematic set: comparison of PMs from systematic review and PitNETs from original series. This table also shows results from regression analyses for diagnosis of PMs. Bold values represent significant p-values (< 0.05)

2A

		Local set			Regression for PMs	
		PitNETs (n = 361)	PMs (n = 6)	p value	OR (95% CI)	p value
Demographics	Age [years]	45.3 ± 12.3	69.3 ± 7.7	**0.02**	1.12 (0.98–1.86)	0.056
	Gender (F/M)	157/204	4/2	0.70	0.87 (0.55–1.12)	0.54
	Oncological history	25 (7%)	3 (50%)	**0.007**	1.89 (1.39–2.30)	**0.001**
	Incidental finding	99 (27%)	0 (0%)	0.19	0.60 (0.09–1.12)	0.54
	Headaches	45 (12%)	4 (67%)	**0.003**	1.20 (1.09–1.29)	**0.001**
	Visual field deficits	147 (41%)	5 (83%)	**0.04**	1.24 (1.02–1.78)	**0.03**
	Extraocular muscle palsy	43 (12%)	3 (50%)	**0.02**	1.12 (1.05–1.26)	**0.03**
	Acute onset (< 6 months)	59 (16%)	4 (67%)	**0.009**	1.25 (1.11–1.75)	**0.001**
Hormonal	Diabetes insipidus	3 (1%)	4 (67%)	**< 0.001**	2.01 (1.46–2.67)	**< 0.001**
	Hypopituitarism	142 (39%)	4 (67%)	0.22	0.99 (0.38–1.52)	0.33
Imaging	Mean volume [cm^3]	2.3 ± 1.4	5.7 ± 1.3	**0.03**	1.87 (1.12–2.01)	**0.04**
	Sellar enlargement	201 (56%)	0 (0%)	**0.008**	0.54 (0.04–0.84)	**0.001**
	Sellar walls erosion	42 (12%)	4 (67%	**0.003**	1.55 (1.05–2.43)	**0.002**
	T2w cyst	23 (6%)	0 (0%)	1.00	0.89 (0.22–1.45)	0.98
	T2w flow voids	2 (1%)	1 (17%)	**0.04**	1.78 (1.09–2.01)	**0.03**
	Cavernous sinus invasion	56 (15%)	4 (67%)	**0.008**	1.89 (1.18–2.39)	**0.006**
	Stalk/infundibular involvement	5 (1%)	2 (33%)	**0.005**	1.86 (1.14–2.37)	**0.009**
	Suprasellar extension	169 (47%)	4 (67%)	0.42	1.01 (0.51–1.51)	0.67
Gross appearance	Firm	26 (7%)	5 (83%)	**< 0.001**	2.01 (1.47–2.63)	**< 0.001**
	Easily bleeding	12 (3%)	4 (67%)	**< 0.001**	1.99 (1.48–2.56)	**< 0.001**

2B

		Systematic set			Regression for PMs	
		PitNETs (n = 361)	PMs (n = 348)	p-value	OR (95% CI)	p value
Demographics	Age [years]	45.3 ± 12.3	–	–	–	–
	Gender (F/M)	157/204	–	–	–	–
	Oncological history	25 (7%)	–	–	–	–
	Incidental finding	99 (27%)	20 (6%)	**< 0.001**	0.49 (0.08–1.15)	**< 0.001**
	Headaches	45 (12%)	73 (21%)	**0.001**	1.24 (1.07–1.99)	**0.001**
	Visual field deficits	147 (41%)	171 (49%)	**0.01**	1.19 (1.06–1.82)	**0.02**
	Extraocular muscle palsy	43 (12%)	117 (34%)	**< 0.001**	1.23 (1.10–2.01)	**0.001**
	Acute onset (< 6 months)	59 (16%)	–	–	–	–
Hormonal	Diabetes insipidus	3 (1%)	77 (22%)	**< 0.001**	2.13 (1.36–2.78)	**< 0.001**
	Hypopituitarism	142 (39%)	154 (45%)	0.16	1.01 (0.45–1.70)	0.45
Imaging	Mean volume [cm^3]	2.3 ± 1.4	9.8 ± 16	**0.003**	1.97 (1.17–2.11)	**0.001**
CT imaging	Sellar enlargement	201 (56%)	–	–	–	–
	Sellar walls erosion	42 (12%)	–	–	–	–
	T2w cyst	23 (6%)	9 (3%)	**0.01**	0.77 (0.19–0.97)	**0,02**
	T2w flow voids	2 (1%)	11 (3%)	**0.01**	1.13 (1.02–1.76)	**0.001**
	Cavernous sinus invasion	56 (15%)	84 (24%)	**0.003**	1.57 (1.13–2.03)	**0.004**
	Stalk/infundibular involvement	5 (1%)	55 (16%)	**< 0.001**	1.98 (1.12–2.45)	**0.001**
	Suprasellar extension	169 (47%)	182 (52%)	0.14	1.01 (0.43–1.12)	0.34
Gross appearance	Firm	26 (7%)	–	–	–	
	Easily bleeding	12 (3%)	–	–	–	

Table 3. Single PM cases

ID	Sex	Age	Primary tumour	Tumour History	Pituitary dysfunction	Visual/eye dysfunction	Volume [cm^3]	MRI	CT	Gross appearance	EOR	Adj therapies	OS (m)	Cause of death
1	F	55	Breast	no	Partial AH	VI cn palsy	8	T1, T2 iso cav sinus CE homo +	floor erosion	Firm	STR	SRS-RT Chemo	8	Intracranial disease progression
2	F	74	Thyroid	yes	Partial AH DI	VI cn palsy VA / VF	6.5	T1 iso, T2 void cav sinus suprasellar CE hetero +	dorsum erosion	Soft, bleeding	STR	SRS-RT Chemo	14	Systemic disease progression
3	F	72	Lung (NSCLC)	yes	Complete AH DI	VF	5.6	T1 hypo, T2 iso cav sinus CE hetero +	dorsum + clivus erosion	Firm, bleeding	STR	none	0.5	Hypothalamic syndrome
4	M	77	Lung (NSCLC)	no	DI	Headache VA / VF	4.3	T1, T2 iso suprasellar stalk CE homo +	sella unchanged	Firm, bleeding	GTR	SRS-RT Chemo Immuno	10	Intracranial disease progression
5	M	67	Lung (NSCLC)	no	DI	VA / VF	4.6	T1, T2 iso suprasellar stalk CE homo +	sella unchanged	Firm, bleeding	GTR	SRS-RT Chemo Immuno	9	Systemic disease progression
6	F	71	Breast	yes	Complete AH	VI cn palsy VA / VF	5.2	T1, T2 iso cav sinus suprasellar CE homo +	dorsum erosion	Firm	STR	SRS-RT Chemo	6	Intracranial disease progression

Partial AH — partial anterior hypophysis deficit; complete AH — partial anterior hypophysis deficit; CE — contrast-enhancement; chemo — chemotherapy; cn — cranial nerve; DI — diabetes insipidus; hetero — heterogeneous; homo — homogeneous; hypo — hypo-intense; iso — iso-intense; NSCLC — non-small cell lung carcinoma; SRS-RT — stereotactic radiotherapy; VA — visual acuity; VF — visual field cuts

Table 4. Baseline blood and urine analyses of original series PMs cases

			Patient ID #					
Parameter	Normal range	Units	1	2	3	4	5	6
Plasma osmolality	280–295	mOsm/kg	289	308	302	306	303	290
Urine osmolality	500–800	mOsm/kg	790	270	127	267	112	680
Sodium	136–146	mEq/L	139	152	154	147	149	140
Potassium	3.5–5.1	mEq/L	3.8	4.8	4.9	4.2	5	4.1
Somatotropic hormone (GH)	0.05–5	ng/mL	0.02	0.03	0.01	0.22	1.1	0.03
Prolactin	0–17	ng/mL	12	47	12	125	187	8
Free triiodothyronine (fT3)	2–4.4	ng/dL	2.1	2.3	1.5	3.5	3.7	1.1
Free thyroxine (fT4)	0.9–1.7	ng/dL	1.1	1.3	0.6	1.3	1.5	0.52
TSH	0.25–5	mIU/mL	0.35	0.40	0.18	1.01	0.90	0.12
ACTH	7.2–52	pg/mL	8.7	9.0	6.1	17.3	23.4	4.5
Cortisol	48–195	ng/dL	52	56	36	118	125	32
Follicle-stimulating (FSH)	25–134.8	mIU/mL	18	19	19	2.8	3.0	12
Luteinising (LH)	7.7–58.5	mIU/mL	6.5	5.4	5.6	4.7	2.5	4.3
Oestradiol	< 36	pg/mL	29	32	28	18	22	23

95% CI 1.46–2.67, p < 0.001), increased lesional volume (OR 1.87, 95% CI 1.12–2.01, p = 0.04), sellar wall erosions (OR 1.55, 95% CI 1.05–2.43, p = 0.002), stalk/infundibular involvement (OR 1.86, 95% CI 1.14–2.37, p = 0.009), cavernous sinus invasion (OR 1.89, 95% CI 1.18–2.39, p = 0.006), T2w flow voids (OR 1.78, 95% CI 1.09–2.01, p = 0.03), firm lesion (OR 2.01, 95% CI 1.47–2.63, p < 0.001) and haemorrhagic lesion (OR 1.99, 95% CI 1.48–2.56, p < 0.001). Conversely, sellar enlargement predicted a lower risk of PMs (OR 0.54, 95% CI 0.04–0.84, p = 0.001).

Illustrative case (number 3)

A 72-year-old woman with a 36-year smoking history received a diagnosis of NSCLC in 2021. The patient underwent lobectomy in August 2021, followed by radiotherapy and chemotherapy. In March 2022, she presented to A&E with severe headaches and blurred vision that had developed within the previous three months. Upon examination, she was alert and oriented and in moderate distress, complaining of generalised aches, bone pain, and difficulty with her vision. Her neurological examination was limited by extreme discomfort, as she felt better with both eyes closed. She maintained central vision but was unable to see well peripherally. A brain MRI with pituitary protocol demonstrated a pituitary lesion with a 5.6 cm^3 volume extending into the suprasellar cistern, causing a mass effect on the optic chiasm without evidence of other metastatic cerebral lesions (Fig. 1). Given the presence of a rapidly growing pituitary lesion, the possibility of metastatic disease from a primary malignancy was considered. Computed tomography of the chest, abdomen, and pelvis with contrast did not show other metastatic lesions. Values of low cortisol, adrenocorticotropic hormone (ACTH), free thyroxine (T4), triiodothyronine (T3), thyroid-stimulating hormone (TSH), follicle-stimulating hormone (FSH), and luteinising hormone (LH) were consistent with complete hypopituitarism. Increased serum sodium levels and serum osmolality with reduced urine osmolality were consistent with DI. The patient underwent endoscopic TNS surgery. The lesion was firm and difficult to remove, particularly in its suprasellar portion. Only STR was achieved. The frozen section showed the mass to be a metastatic carcinoma. The final histopathological report was metastatic non-small cell carcinoma/adenocarcinoma with primary lung origin. A post-operative CT scan with contrast was performed three days after surgery (Fig. 2), which did not demonstrate peri-operative complications. After the diagnosis, the patient was sent for definitive management in the Oncology department. She died two weeks after surgery, following the development of non-medically treatable hypothalamic syndrome.

Systematic review

Our systematic review of the literature available in international databases yielded 11,910 references. After removing duplicates, we screened 8,088 records on a title/abstract to exclude irrelevant papers. The search process, including selection and exclusion reasons, is illustrated in Figure 3. After scanning the titles and abstracts, 299 studies were retained for further analysis. A total of 149 papers were considered eligible for inclusion [2, 5, 8–154]. These works reported the clinical

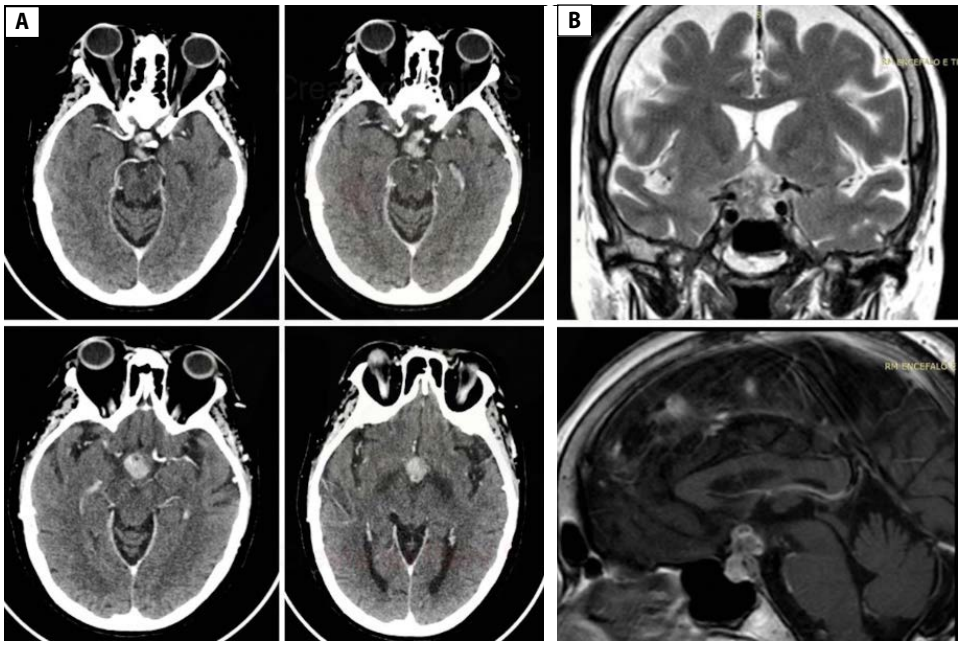

Figure 1. Illustrative case. CT scan (**A**) and brain MRI study (**B**) with pituitary protocol, performed in March 2022 for onset of headache and blurred vision. Demonstrates a pituitary lesion extending into suprasellar cistern causing mass effect on optic chiasm, without evidence of another metastatic cerebral lesion

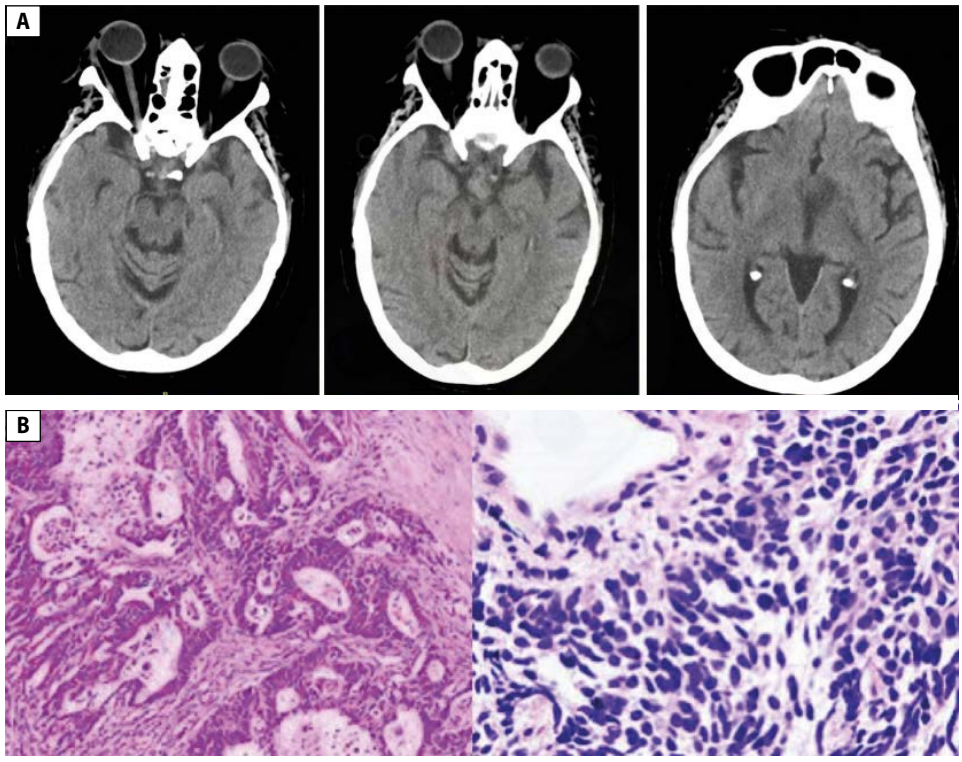

Figure 2. A. Post-operative CT scan with contrast was performed three days after surgery. **B**. Final histopathological report was metastatic non-small cell carcinoma/adenocarcinoma with primary lung origin

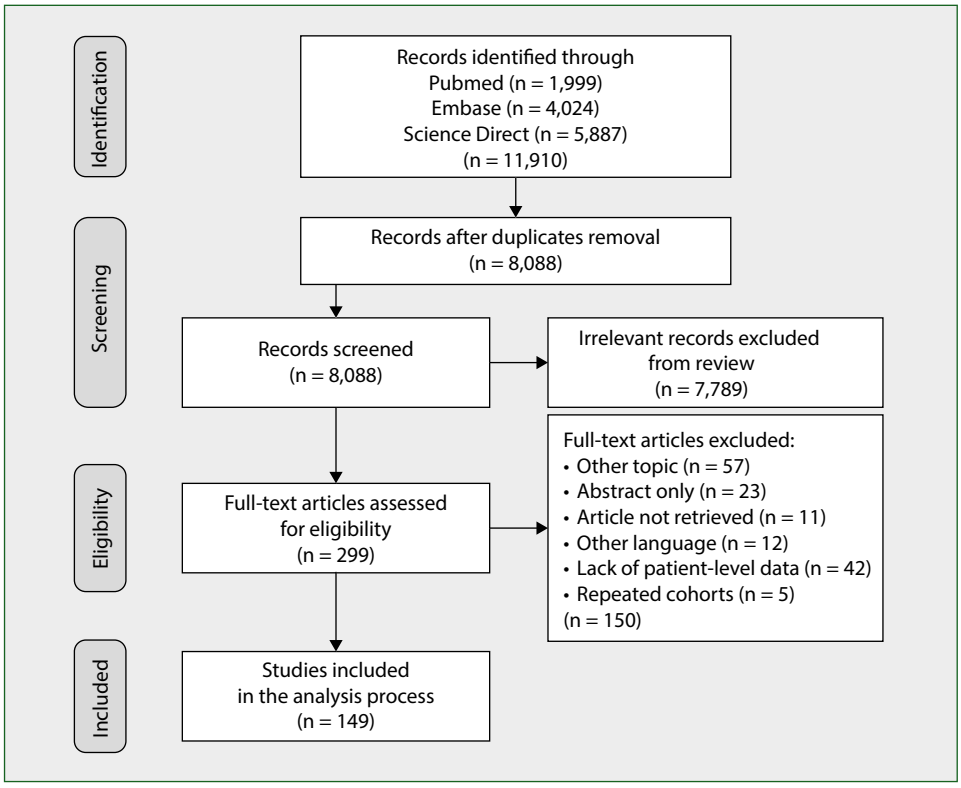

Figure 3. Systematic literature review process, including selection and exclusion criteria

and neuroradiological details of n = 340 PMs. Data from our original series (n = 6 PMs) was aggregated with the retrieved cases. The list of articles and retrieved lesions is shown in Supplementary Table 1.

Studies, patients, and PM characteristics

Reports spanned 1982 to 2024. Most of the retrieved studies were single case reports, while 21 works reported case series. 346 PMs were included in the final analysis. Most of the lesions originated from lung cancer (n = 73, 21%), followed by breast (n = 52, 15%), neuroendocrine tumours (n = 46, 13%), thyroid (n = 39, 11%), kidney (n = 37, 11%), gastro-intestinal (n = 22, 6%), liver (n = 19, 5%), prostate (n = 13, 4%), salivary glands (n = 8, 2%), sarcomas (n = 5, 1%), melanomas (n = 5, 1%), haematological malignancies (n = 4, 1%), and gynaecological tumours (n = 3, 1%). Among the rarest aetiologies were choroid plexus carcinoma (n = 1, 0.5%), thymoma (n = 1, 0.5%), and carcinoid tumour (n = 1, 0.5%). In n = 17 cases (5%), the tumour was a poorly differentiated carcinoma, adenocarcinoma, or a cancer of unknown origin.

Pituitary metastases were detected as incidental findings in n = 20 (6%) cases. Symptoms at presentation included visual field cuts in n = 171 (49%), extraocular muscle palsies in n = 117 (34%), and headaches in n = 73 (21%). Partial or complete anterior hypophysis dysfunction was present in n = 154 (45%), while DI was present in n = 77 (22%) patients. The mean lesional volume was 9.8 ± 16 cm^3. Lesions showed various degrees of CE in n = 316 (91%) cases. The cavernous sinus was invaded in n = 84 PMs (24%), and the pituitary stalk was thickened with infundibular involvement in n = 55 (16%). T2w flow voids were recorded in n = 11 (3%), and cystic changes in n = 9 (3%). This review did not capture features of enlarged or eroded sella because most of the retrieved articles did not report this data.

Pituitary metastases vs. PitNET (systematic set)

Compared to PMs, PitNETs overall presented as smaller lesions (2.3 ± 1.4 vs. 9.8 ± 16 cm^3, p = 0.003) and were more often seen as incidental lesions (27% vs. 6%; p < 0.001), see Table 2B. PitNETs presented a reduced incidence of headaches (12% vs. 21%; p = 0.001), visual deficits (41% vs. 49%; p = 0.01), oculomotor muscle palsies (12% vs. 34%; p < 0.001), and DI (1% vs. 22%; p < 0.001), while the incidence of anterior hypophysis dysfunction did not significantly differ from PMs (39% vs. 45%; p = 0.16). PitNETs showed a similar suprasellar extension compared to PMs (47% vs. 52%, p = 0.14) but significantly less cavernous sinus invasion (15% vs. 24%; p = 0.003), stalk/infundibular involvement (1% vs. 16%; p < 0.001), and T2w flow voids (1% vs. 3%; p = 0.01) and more frequent cystic lesions (6% vs. 3%; p = 1.00).

Regression analysis revealed a strong predictive role for PMs for the presence of headaches (OR 1.24, 95% CI 1.07–1.99, p = 0.001), visual field cuts (OR 1.19, 95% CI 1.06–1.82, p = 0.02), extraocular muscle palsies (OR 1.23, 95% CI 1.10–2.01, p = 0.001), diabetes insipidus (OR 2.13, 95% CI 1.36-2.78, p < 0.001), increased lesional volume (OR 1.97, 95% CI 1.17–2.11, p = 0.001), stalk/infundibular involvement (OR 1.98, 95% CI 1.12–2.45, p = 0.001), cavernous sinus invasion (OR 1.57, 95% CI 1.13–2.03, p = 0.004), and T2w flow voids (OR 1.13, 95% CI 1.02–1.76, p = 0.001). Conversely, the incidental finding of a pituitary lesion and the presence of cystic changes predicted a lower risk of PMs (OR 0.49, 95% CI 0.08–1.15, p < 0.001, and OR 0.77, 95% CI 0.19–0.97, p = 0.02, respectively).

Red flags for PMs

Driven by data from our systematic review and our single-centre experience, we propose that the parameters shown in Table 5 be used as red flags for suspecting PMs in the context of a sellar mass.

Clinical parameters validated from the systematic review database (i.e. primary parameters) included that lesions were *not diagnosed as incidental*, and presented with *visual field deficits*, *extraocular muscle palsies*, *headache*, and *DI*. Features only validated from the original series (i.e., secondary parameters) included the presence of an *oncological history*, an *acute onset of symptoms,* and the intraoperative features of *firm/easily bleeding lesions*.

Primary radiological parameters include the *presence of cavernous sinus invasion*, *pituitary stalk/infundibular involvement*, *T2w flow voids,* and the *absence of T2w cystic lesions*. Secondary parameters comprise CT-based *demonstration of sellar wall erosion* and *absence of sellar enlargements*.

Discussion

Clinical presentation and intraoperative findings

In this work, we report an original series of 361 PitNETs and six PMs treated over 10 years in a single center. The PitNETs series comprised 42% NF-PitNETs, 39% prolactinomas, 11% GH, and 6% ACTH-secreting tumours. Their relative rate was not different from that reported in other series [155]. They were incidentally discovered in 27% of cases, while visual deficits were the presenting symptom in 41%, cranial nerve palsies and headaches in 12%, and hypopituitarism of any extent in 39%. Diabetes insipidus was rare and observed in only 1%. Previous reports presented similar results, with about 10-38% of PitNETs being incidentally discovered [156, 157], visual deficits including visual acuity disturbances or visual field cuts being the most common presenting complaint (37% to 96%)[158, 159], and only a small subset of patients (5–17%) presenting extraocular muscle palsies due to cranial nerve deficits following cavernous sinus invasion or due to extensive suprasellar extension [160]. Large lesions (> 1 cm) generally account for about 50% of lesions in large PitNETs series [159] and are associated with partial or complete hypopituitarism in a subgroup estimated at 6–85% [161]. Overall, however, severe hypopituitarism is not considered

Table 5. Clinical and neuroradiological red flags to be considered in differential diagnosis on pituitary lesions

	Suspected PM	Suspected PitNET
Primary features	**Suspected PM**	**Suspected PitNET**
Clinical	Symptomatic lesion	Incidental lesion
	Visual field cuts	Asymptomatic
	Extraocular muscle palsies	–
	Headache	–
	DI	–
Neuroradiological	Stalk/infundibular involvement	Not involving
	Cavernous sinus invasion	Not invading
	T2w flow void	No flow voids
	No cysts	Cystic lesion
Secondary features		
Clinical	Oncological history	No oncological history
	Acute onset (< 6 months)	Non acute
Neuroradiological	Sellar erosion	Sellar enlargement
Intraoperative	Firm lesion	Soft
	Easy to bleed	Not bleeding
Clinical	Symptomatic lesion	Incidental lesion
	Visual field cuts	Asymptomatic
	Extraocular muscle palsies	–
	Headache	–
	DI	–
Neuroradiological	Stalk/infundibular involvement	Not involving
	Cavernous sinus invasion	Not invading
	T2w flow void	No flow voids
	No cysts	Cystic lesion
Secondary features		
Clinical	Oncological history	No oncological history
	Acute onset (< 6 months)	Non acute
Neuroradiological	Sellar erosion	Sellar enlargement
Intraoperative	Firm lesion	Soft
	Easy to bleed	Not bleeding
Primary features	**Suspected PM**	**Suspected PitNET**
Clinical	Symptomatic lesion	Incidental lesion
	Visual field cuts	Asymptomatic
	Extraocular muscle palsies	–
	Headache	–
	DI	–
Neuroradiological	Stalk/infundibular involvement	Not involving
	Cavernous sinus invasion	Not invading
	T2w flow void	No flow voids
	No cysts	Cystic lesion
Secondary features		
Clinical	Oncological history	No oncological history
	Acute onset (< 6 months)	Non acute
Neuroradiological	Sellar erosion	Sellar enlargement
Intraoperative	Firm lesion	Soft
	Easy to bleed	Not bleeding

a common finding in PitNETs. Even rarer is DI, confirmed in approximately 1–2% of PitNETs [162].

The original PMs series included metastases from NSCLC in 50% of cases, breast in 33%, and thyroid in 17%. Compared to PitNETs, patients more frequently had an oncological history and presented with an acute onset of visual deficits, headaches, and extraocular muscle palsies. The occurrence of hypopituitarism was only slightly increased, yet DI was strikingly more common among PMs (67%). Intraoperatively, PMs had a firm/hard texture in 83% and a relative ease of bleeding in 67%. These findings substantially differed from what was reported during PitNETs surgery, where these features were recorded in only 7% and 3%, respectively.

To better define the clinical and neuroradiological presentation features of PMs, we conducted a systematic review to retrieve individual patients' data and compare them to our original series of PitNETs. Overall, 348 PMs were included. According to a recent work [134], PMs more commonly originated from lung and breast cancer (21% and 15%, respectively) and less commonly from the kidney, gastrointestinal tract, thyroid, and prostate. Retrieved PMs presented a significantly higher incidence of visual field deficits, extraocular muscle palsies, headaches, and DI than PitNETs from our original series. The hypopituitarism rate, however, did not significantly increase, despite some authors having reported it as a presenting feature of PMs [4, 163, 164]. PMs prompted clinical attention in 94% of cases. Therefore, their presentation as incidental lesions was significantly less frequent than that observed in patients with PitNET.

These differences in clinical presentation had been previously highlighted in several reviews [4, 28, 51, 165, 166] reporting an increased incidence of cranial nerve palsies, visual deficits, and central DI, primarily due to an observed predilection of metastases for the posterior lobe, their rapid growth, and aggressiveness towards the surrounding structures. The authors also postulated a more rapid compression of the optic pathway in the context of PMs. Among the explanatory mechanisms were the involvement of the hypothalamus-hypophyseal portal system, metastatic extension from the skull base or para-sellar region (clivus, dorsum sellae, or cavernous sinus), and leptomeningeal spread to the pituitary gland. It has been suggested that DI and the presence of ophthalmoplegia are independent predictors of PMs in multivariate analysis [6]. The data we present here, therefore, provides a list of parameters that could be used as clinical red flags in the differential diagnosis of PMs in the context of sellar lesions.

Neuroimaging

Differential diagnosis of PMs from other sellar lesions is often difficult, especially when no history of primary malignancy is present. MRI usually reveals a non-homogeneous invasive sellar lesion with iso-/hypo-intensity on T1w sequences (hyperintense if haemorrhagic), various degrees and heterogeneity of CE, and inconsistent T2w features. Suprasellar and para-sellar extensions are typical, with a characteristic 'dumbbell' shape on the sagittal view due to the rapid growth, which does not let the diagram accommodate the rising lesional volume [39, 165]. PMs may demonstrate a more invasive pattern involving the infundibulum and hypothalamus, with irregular edges and dural thickening [4, 95]. Loss of the posterior lobe bright spot and sellar wall sclerosis (bright T1w and T2w) can also be seen. However, PitNETs tend to appear hypointense or isointense relative to the normal pituitary gland in T1w, and isointense or hyperintense in T2w, with a cystic appearance in up to 6% of cases [167]. They typically present a homogeneous CE but less intense compared to the normal pituitary gland [157].

Analysing the original series and the PMs retrieved from the systematic review, we observed that PMs had a mean larger volume at presentation than PitNETs. No differences were found in the quality and extent of CE or the rate of suprasellar extension. However, PMs demonstrated a significantly increased incidence of cavernous sinus invasion, pituitary stalk infundibular involvement, and T2w flow voids. The rate of cystic changes was not different when analyzing the original series; however, it became significantly higher among PitNETs when analyzing data from the systematic review.

CT imaging can help to define changes in the bone walls that limit the sella turcica. In particular, PM growth is thought to be associated with a relatively normal-sized fossa (due to rapid growth) with bony erosion and destruction rather than remodelling. On the contrary, enlargement of sella is more commonly expected in PitNETs, where erosion is rare and observed only with large, aggressive PitNETs [159, 168]. Unfortunately, CT data have been reported inconsistently in the literature; therefore, we were only able to analyze data from our original series.

We concluded, as expected, that PMs were more commonly associated with sellar erosion and less frequently with sellar enlargement. Many other reviews have reported similar results [4, 63, 95, 169, 170]. Only the addition of oedematous response in the adjacent portion of the brain, compression of neural tissue or vessels, leptomeningeal extensions, or multiplicity of metastases should suggest a diagnosis of PMs. Functional imaging with PET-FDG to differentiate PitNETs from metastasis is of limited value because a pituitary PitNET can also appear as a hypermetabolic sellar mass [171].

Management of pituitary metastases

The management of PMs primarily depends on the severity of neurological and endocrinological deficits, as well as the extent of systemic disease spread [2, 51, 165]. The management goal is to provide symptomatic relief, a favourable impact on quality of life, to prevent further enlargement, and, if possible, to provide histological confirmation. The occurrence of PMs is associated with aggressive disease and reduced life expectancy, with earlier series having reported mean survival times of 6–7 months [172] primarily because of the multiple peripheric and often intracerebral metastases. Survival also

depends on the type of primary cancer and the availability of systemic treatments, including target therapies and immunotherapeutic approaches.

Surgical resection is often complicated, and the rate of GTR is particularly low, as these lesions tend to be invasive [3, 89, 172]. In our single-centre experience, only STR could be achieved in most cases due to invasion of the cavernous sinus, adherence to visual pathways, hard texture, and tendency to bleed. These features were significantly more common among PMs than PitNETs. Unfortunately, the intraoperative gross appearance information was not consistently reported in retrieved articles. Therefore, we were unable to perform a formal analysis between the two populations. In our centre, all patients underwent endoscopic TNS surgery and experienced a complete resolution of their headaches and amelioration of visual deficits in 33%, while oculomotor palsies did not improve. Other authors [68, 69] have reported incomplete resolution of pre-operative symptoms in the context of PMs, particularly in ophthalmological symptoms and endocrinological dysfunctions. However, an aggressive approach with surgical decompression and postoperative irradiation is currently seen as desirable in symptomatic patients to improve quality of life, despite an apparent lack of evidence regarding an impact on OS [68, 89, 172]. Our original series did not reveal an increased risk for peri-operative significant complications, including surgical bed haemorrhage, CSF leaks, infarcts, or infections. This is consistent with other reports describing a minimal increase in the surgical risk among PMs [1, 17]. The described ease of bleed observed in PMs may only influence a reduced likelihood of GTR. No studies have suggested a preferred surgical strategy to improve disease control and mitigate complications.

The postoperative adjuvant treatment modalities depend on the underlying condition, the stage, and the patient's performance status. The strategies include radiotherapy (stereotactic radiosurgery, external beam RT, or whole brain RT) and systemic chemotherapies. Patients included in our original series received postoperative treatments; the mean OS was less than nine months. Notably, the expected OS rate at 12 months was found to be no more than 10% in a review of PM cases [173]. In selected cases, stereotactic radiosurgery has been proposed as a minimally invasive outpatient management strategy for treating PMs, resulting in effective local control rates [89, 174, 175]. The presence of multiple intracranial metastatic lesions, leptomeningeal disease, and/or small-cell lung tumour histology may require WBRT.

No apparent prognostic factors exist for OS in PM patients. Only a few authors [1] have investigated the topic. They found that younger age, late metastasis to the pituitary gland, smaller lesion size, and irradiation were associated with a better prognosis. Patients with breast and renal carcinomas had a better rate of survival than did patients with lung cancer [1]. Similarly, Morita et al. [68] demonstrated an improvement in survival, along with the amelioration of disabling symptoms and local tumor control, using a multimodality approach that included surgery, radiation, and chemotherapy.

Additional, extensive, prospective studies are necessary to elucidate further the ideal diagnostic, management, and surgical approach for patients with PMs.

Limitations

The limitations of our study include the small sample size of the PM series and its retrospective design. Additionally, the systematically reviewed cases were compared to a local series of PitNETs, which precluded the performance of a formal meta-analysis or multivariate analysis of predictors. For this reason, this study could only provide a list of parameters without additional scoring information. A larger dataset and multicentric data analysis are warranted to uncover the reciprocal influence of these parameters in a predictive model of PMs.

Conclusions

This study has analysed one of the most extensive series of PMs, a rare condition that is challenging to study due to limited case availability. By systematically comparing this extensive PM cohort with a well-defined local control group, we have gained unique insights into its clinical characteristics, thereby facilitating a better understanding of this uncommon entity.

Pituitary metastases are a rare clinical condition and have traditionally been deemed to carry a poor prognosis. They are associated with severe neurological and endocrinological disturbances that can mimic the neuroradiological features of PitNETs. We propose a list of clinical and neuroradiological red flags to raise the suspicion of PMs in the context of sellar lesions to inform a timely diagnosis plus a multimodality approach, including surgery for tumour debulking and histological confirmation, followed by postoperative adjuvant treatments.

Article information

Data availability statement: *The authors confirm that the data supporting the findings of this study is available within the article, figures, and tables.*

Ethics statement: *All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The ethical review process and approval by our ethics committee were not required for the present study because it was a retrospective study on patients who required a life-saving intervention. Furthermore, the research data analysis does not affect the participants and their medical care.*

Authors' contributions: *RAR, RP: substantial contributions to conception or design of manuscript; FM, SP: acquisition of data; VR, DM, FRB, MMO, PDD: contributions to analysis and interpretation of data. All authors participated in drafting manuscript, and RAR revised it critically. All authors read and approved final version of manuscript.*

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References

1. Habu M, Tokimura H, Hirano H, et al. Pituitary metastases: current practice in Japan. J Neurosurg. 2015; 123(4): 998–1007, doi: 10.3171/2014.12.JNS14870, indexed in Pubmed: 26186025.
2. He W, Chen F, Dalm B, et al. Metastatic involvement of the pituitary gland: a systematic review with pooled individual patient data analysis. Pituitary. 2015; 18(1): 159–168, doi: 10.1007/s11102-014-0552-2, indexed in Pubmed: 24445565.
3. Castle-Kirszbaum M, Goldschlager T, Ho B, et al. Twelve cases of pituitary metastasis: a case series and review of the literature. Pituitary. 2018; 21(5): 463–473, doi: 10.1007/s11102-018-0899-x, indexed in Pubmed: 29974330.
4. Fassett D, Couldwell W. Metastases to the pituitary gland. Neurosurgical Focus. 2004; 16(4): 1–4, indexed in Pubmed: 15191337.
5. Zhao Yi, Lian W, Xing B, et al. Diagnosis, therapy, and therapeutic effects in cases of pituitary metastasis. World Neurosurg. 2018; 117: 122–128, doi: 10.1016/j.wneu.2018.05.205, indexed in Pubmed: 29883826.
6. Al-Aridi R, El Sibai K, Fu P, et al. Clinical and biochemical characteristic features of metastatic cancer to the sella turcica: an analytical review. Pituitary. 2014; 17(6): 575–587, doi: 10.1007/s11102-013-0542-9, indexed in Pubmed: 24337713.
7. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. J Clin Epidemiol. 2021; 134: 178–189, doi: 10.1016/j.jclinepi.2021.03.001, indexed in Pubmed: 33789819.
8. Alhashem A, Taha M, Almomen A. Pituitary metastasis of lung adenocarcinoma: Case report and literature review. Int J Surg Case Rep. 2020; 67: 98–101, doi: 10.1016/j.ijscr.2020.01.013, indexed in Pubmed: 32058309.
9. Al Hassan MS, El Ansari W, Alater A, et al. Choroidal metastasis as initial presentation of aggressive medullary thyroid carcinoma with widespread mediastinal, brain, pituitary, bone, lung, and liver metastasis: Case report and literature review. Int J Surg Case Rep. 2021; 87, doi: 10.1016/j.ijscr.2021.106419, indexed in Pubmed: 34597971.
10. Ataikiru O, Abdelsalam M, Avileli M, et al. Prostate cancer metastasis to the pituitary gland manifesting as corticosteroid withdrawal, and the impact of the switch from prednisone to dexamethasone on survival time. Curr Oncol. 2021; 28(6): 4291–4297, doi: 10.3390/curroncol28060365, indexed in Pubmed: 34898537.
11. Barbaro D, Desogus N, Boni G. Pituitary metastasis of thyroid cancer. Endocrine. 2013; 43(3): 485–493, doi: 10.1007/s12020-012-9806-9, indexed in Pubmed: 23008095.
12. Benjamin C, Ashayeri K, Golfinos JG, et al. Treatment of sellar metastases with gamma knife radiosurgery in patients with advanced cancer. Pituitary. 2020; 23(6): 665–671, doi: 10.1007/s11102-020-01074-8, indexed in Pubmed: 32860552.
13. Hareez NB, Jay M, Lochnan H. Papillary thyroid cancer with unusual late onset pituitary and orbital choroidal metastases. Case report and literature review. J Clin Transl Endocrinol Case Rep. 2021; 20, doi: 10.1016/j.jecr.2021.100081.
14. Bobinski M, Greco CM, Schrot RJ. Giant intracranial medullary thyroid carcinoma metastasis presenting as apoplexy. Skull Base. 2009; 19(5): 359–362, doi: 10.1055/s-0029-1220202, indexed in Pubmed: 20190947.
15. Burkhardt T, Henze M, Kluth LA, et al. Surgical management of pituitary metastases. Pituitary. 2016; 19(1): 11–18, doi: 10.1007/s11102-015-0676-z, indexed in Pubmed: 26238305.
16. Castle-Kirszbaum M, Beng Phung T, Luen SJ, et al. A pituitary metastasis, an adenoma and potential hypophysitis: A case report of tumour to tumour metastasis in the pituitary. J Clin Neurosci. 2020; 81: 161–166, doi: 10.1016/j.jocn.2020.09.033, indexed in Pubmed: 33222908.
17. Chon H, Yoon K, Kwon DoH, et al. Hypofractionated stereotactic radiosurgery for pituitary metastases. J Neurooncol. 2017; 132(1): 127–133, doi: 10.1007/s11060-016-2346-z, indexed in Pubmed: 28070828.
18. Chuang YC, Tsai CC. Pituitary metastasis of breast cancer: a case report. Int J Gerontol. 2018; 12(3): 267–270, doi: 10.1016/j.ijge.2017.06.004.
19. Coşkun M, Soykut ED, Güney Y, et al. Symptomatic infundibulum metastasis from breast cancer and resolution of symptoms following Cyberknife® fractionated stereotactic radiotherapy: case report. Turk Klin J Med Sci. 2013; 33(1): 272–278, doi: 10.5336/medsci.2011-25685.
20. Couldwell WT, Chandrasoma PT, Weiss MH. Pituitary gland metastasis from adenocarcinoma of the prostate. Case report. J Neurosurg. 1989; 71(1): 138–140, doi: 10.3171/jns.1989.71.1.0138, indexed in Pubmed: 2661740.
21. Dabbous Z, Mohamed M, Benjamin S, et al. A tale of many tumors and one endocrine site: A case series of pituitary metastases. Qatar Med J. 2021; 2021(2): 38, doi: 10.5339/qmj.2021.38, indexed in Pubmed: 34540600.
22. Dedeker C, Archibald H, Meares A, et al. Metastatic breast cancer masquerading as a pituitary macroadenoma: A case report. SAGE Open Med Case Rep. 2022; 10, doi: 10.1177/2050313X211073243, indexed in Pubmed: 35096396.
23. Di Nunno V, Mollica V, Corcioni B, et al. Clinical management of a pituitary gland metastasis from clear cell renal cell carcinoma. Anticancer Drugs. 2018; 29(7): 710–715, doi: 10.1097/CAD.0000000000000644, indexed in Pubmed: 29846249.
24. Eksi MS, Hasanov T, Yilmaz B, et al. Isolated metastasis of breast cancer to the pituitary gland. Neurol India. 2014; 62(1): 70–71, doi: 10.4103/0028-3886.128322, indexed in Pubmed: 24608461.
25. Ersoy R, Topaloglu O, Aydin C, et al. Pituitary metastasis of breast cancer confirmed by fluorine-18 fluorodeoxyglucose positron emission tomography: a case report. J Endocrinol Invest. 2007; 30(6): 532–533, doi: 10.1007/BF03346341, indexed in Pubmed: 17646732.

26. Feiz-Erfan I, Rao G, White WL, et al. Efficacy of trans-septal transsphenoidal surgery in correcting visual symptoms caused by hematogenous metastases to the sella and pituitary gland. Skull Base. 2008; 18(2): 77–84, doi: 10.1055/s-2007-991105, indexed in Pubmed: 18769652.
27. Gopan T, Toms SA, Prayson RA, et al. Symptomatic pituitary metastases from renal cell carcinoma. Pituitary. 2007; 10(3): 251–259, doi: 10.1007/s11102-007-0047-5, indexed in Pubmed: 17541748.
28. Goulart CR, Upadhyay S, Ditzel Filho LFS, et al. Newly diagnosed sellar tumors in patients with cancer: a diagnostic challenge and management dilemma. World Neurosurg. 2017; 106: 254–265, doi: 10.1016/j.wneu.2017.06.139, indexed in Pubmed: 28673886.
29. Grossman R, Maimon S, Levite R, et al. Multimodal treatment of hemorrhagic pituitary metastasis as first manifestation of renal cell carcinoma. World Neurosurg. 2013; 79(5-6): 798.E1–798.E5, doi: 10.1016/j.wneu.2012.09.006, indexed in Pubmed: 22990000.
30. Gupta V, Aggarwal K, Nishant P, et al. Rare case of sellar and suprasellar metastasis from Ewing's sarcoma of Tibia. J Neurosci Rural Pract. 2019; 10(1): 158–161, doi: 10.4103/jnrp.jnrp_139_18, indexed in Pubmed: 30765996.
31. Starc MT, Rosenblum MK, Meyers PA, et al. Rare presentation of Ewing sarcoma metastasis to the sella and suprasellar cistern. Clin Imaging. 2017; 41: 73–77, doi: 10.1016/j.clinimag.2016.10.017, indexed in Pubmed: 27816880.
32. Zagzoog N, Ra G, Koziarz A, et al. Metastatic Liposarcoma of the Skull Base: A Case Report and Review of Literature. Neurosurgery. 2017; 80(4): 219–223, doi: 10.1093/neuros/nyw157, indexed in Pubmed: 28362929.
33. Ismail E, Issam L, Hamid M. Pituitary metastasis of rhabdomyosarcoma: a case report and review of the literature. J Med Case Rep. 2014; 8: 144, doi: 10.1186/1752-1947-8-144, indexed in Pubmed: 24885254.
34. Ilerhunmwuwa NP, Goldspring R, Page S, et al. Pituitary metastases of Hürthle cell carcinoma of the thyroid. BMJ Case Rep. 2021; 14(1), doi: 10.1136/bcr-2020-239456, indexed in Pubmed: 33462053.
35. Issa D, Thota S, Spiro T, et al. Metastatic colon cancer presenting as pituitary mass. Gastrointest Cancer Res. 2013; 6(5-6): 152–155, indexed in Pubmed: 24312690.
36. Iwai Y, Yamanaka K, Honda Y, et al. Radiosurgery for pituitary metastases. Neurol Med Chir (Tokyo). 2004; 44(3): 112–6; discussion 117, doi: 10.2176/nmc.44.112, indexed in Pubmed: 15095963.
37. Jung S, Hsu Y, Chuang C, et al. A man in his mid-70s with a sellar mass. Brain Pathol. 2007; 17(1): 115–116, 121, doi: 10.1111/j.1750-3639.2007.00044_1.x, indexed in Pubmed: 17493045.
38. Kanayama S, Matsuno A, Nagashima T, et al. Symptomatic pituitary metastasis of malignant thymoma. J Clin Neurosci. 2005; 12(8): 953–956, doi: 10.1016/j.jocn.2004.11.020, indexed in Pubmed: 16326276.
39. Kano H, Niranjan A, Kondziolka D. Stereotactic radiosurgery for pituitary metastases. Surg Neurol. 2009; 72(3): 248–255; discussion 255-256, doi: 10.1016/j.surneu.2008.06.003, indexed in Pubmed: 18786712.
40. Karamouzis MV, Melachrinou M, Fratzoglou M, et al. Hepatocellular carcinoma metastasis in the pituitary gland: case report and review of the literature. J Neurooncol. 2003; 63(2): 173–177, doi: 10.1023/a:1023994604919, indexed in Pubmed: 12825821.
41. Koutourousiou M, Kontogeorgos G, Seretis A. Non-adenomatous sellar lesions: experience of a single centre and review of the literature. Neurosurg Rev. 2010; 33(4): 465–476, doi: 10.1007/s10143-010-0263-8, indexed in Pubmed: 20480381.
42. Kunicki J, Rzewuska N, Maksymowicz M, et al. Metastasis of breast adenocarcinoma to pituitary adenoma. Pol Arch Intern Med. 2021; 131(10), doi: 10.20452/pamw.16052, indexed in Pubmed: 34213297.
43. Lin EY, Hsieh CT, Lin CS, et al. Keyhole surgery for isolated pituitary stalk metastatic tumors: a case report and review of the literature. Minim Invasive Neurosurg. 2008; 51(4): 222–224, doi: 10.1055/s-2008-1062742, indexed in Pubmed: 18683114.
44. He Q, Deng F, Cai B, et al. Pituitary metastasis of hepatocellular carcinoma as the initial presentations: a case report and review of the literature. Front Oncol. 2023; 13, doi: 10.3389/fonc.2023.1123855, indexed in Pubmed: 37483508.
45. Lin HW, Shih SR, Yao M, et al. Relapse of acute myeloid leukemia at the pituitary gland: a case report and review of literature. Endocr Pathol. 2012; 23(3): 172–176, doi: 10.1007/s12022-012-9203-1, indexed in Pubmed: 22527946.
46. Liu X, Wang R, Li M, et al. Pituitary metastasis of lung neuroendocrine carcinoma mimicking pituitary adenoma:case report and literature review. Front Endocrinol (Lausanne). 2021; 12, doi: 10.3389/fendo.2021.678947, indexed in Pubmed: 34335467.
47. Lopes AM, Pereira J, Ribeiro I, et al. Pituitary metastasis unveiling a lung adenocarcinoma. Endocrinol Diabetes Metab Case Rep. 2021 [Epub ahead of print]; 2021, doi: 10.1530/EDM-20-0211, indexed in Pubmed: 33865234.
48. Losa M, Grasso M, Giugni E, et al. Metastatic prostatic adenocarcinoma presenting as a pituitary mass: shrinkage of the lesion and clinical improvement with medical treatment. Prostate. 1997; 32(4): 241–245, doi: 10.1002/(sici)1097-0045(19970901)32:4<241::aid-pros3>3.0.co;2-m, indexed in Pubmed: 9288182.
49. McCutcheon IE, Kitagawa RH, Sherman SI. Adenocarcinoma of the salivary gland metastatic to the pituitary gland: case report. Neurosurgery. 2001; 48(5): 1161–1165, doi: 10.1097/00006123-200105000-00044, indexed in Pubmed: 11334286.
50. Moon RDC, Singleton WGB, Smith P, et al. Slow-Growing pituitary metastasis from renal cell carcinoma: literature review. World Neurosurg. 2021; 145: 416–425, doi: 10.1016/j.wneu.2020.08.218, indexed in Pubmed: 32891842.
51. Mori Y, Kobayashi T, Shibamoto Y. Stereotactic radiosurgery for metastatic tumors in the pituitary gland and the cavernous sinus. J Neurosurg. 2006; 105 Suppl: 37–42, doi: 10.3171/sup.2006.105.7.37, indexed in Pubmed: 18503328.
52. Mormando M, Puliani G, Barnabei A, et al. A rare case of pituitary melanoma metastasis: A dramatic and prolonged response to dabrafenib-trametinib therapy. Front Endocrinol (Lausanne). 2020; 11: 471, doi: 10.3389/fendo.2020.00471, indexed in Pubmed: 32793120.
53. Ozkan C, Arlslan C, Kilic M. Pituitary gland metastasis of breast cancer: A case report. Int J Hematol Oncol. 2012; 22(1): 1–4, doi: 10.4999/uhod.09127.
54. Park Y, Kim H, Kim EH, et al. Effective treatment of solitary pituitary metastasis with panhypopituitarism in HER2-positive breast cancer by lapatinib. Cancer Res Treat. 2016; 48(1): 403–408, doi: 10.4143/crt.2014.165, indexed in Pubmed: 25715765.
55. Patel N, Teh BS, Powell S, et al. Rare case of metastatic prostate adenocarcinoma to the pituitary. Urology. 2003; 65(2): 352, doi: 10.1016/s0090-4295(03)00367-4, indexed in Pubmed: 12893361.
56. Petrakakis I, Pirayesh A, Krauss JK, et al. The sellar and suprasellar region: A "hideaway" of rare lesions. Clinical aspects, imaging findings, surgical outcome and comparative analysis. Clin Neurol Neu-

rosurg. 2016; 149: 154–165, doi: 10.1016/j.clineuro.2016.08.011, indexed in Pubmed: 27540757.
57. Piedra MP, Brown PD, Carpenter PC, et al. Resolution of diabetes insipidus following gamma knife surgery for a solitary metastasis to the pituitary stalk. Case report. J Neurosurg. 2004; 101(6): 1053–1056, doi: 10.3171/jns.2004.101.6.1053, indexed in Pubmed: 15597769.
58. O'Halloran PJ, Hannon AM, Bartels C, et al. Gastrointestinal stromal tumor metastases to the pituitary: a rare entity. Br J Neurosurg. 2017; 31(5): 603–604, doi: 10.3109/02688697.2016.1173194, indexed in Pubmed: 27080418.
59. Prpić M, Fröbe A, Zadravec P, et al. Initial symptomatic pituitary metastasis in a patient with prostate foamy gland carcinoma: tailoring safe and effective therapy. Acta Clin Croat. 2015; 54(2): 243–248, indexed in Pubmed: 26415325.
60. Ragni A, Nervo A, Papotti M, et al. Pituitary metastases from neuroendocrine neoplasms: case report and narrative review. Pituitary. 2021; 24(5): 828–837, doi: 10.1007/s11102-021-01178-9, indexed in Pubmed: 34342837.
61. Rajakumar R, Rahmatullah IH, Rahim AA. Case report of a pituitary metastasis from lung adenocarcinoma masquerading as pituitary adenoma. J ASEAN Fed Endocr Soc. 2020; 35(1): 133–136, doi: 10.15605/jafes.035.01.24, indexed in Pubmed: 33442183.
62. Ravnik J, Smigoc T, Bunc G, et al. Hypophyseal metastases: A report of three cases and literature review. Neurol Neurochir Pol. 2016; 50(6): 511–516, doi: 10.1016/j.pjnns.2016.08.007, indexed in Pubmed: 27633123.
63. Tonolini M, Ferrario S, et al. Occult lung adenocarcinoma mimicking diabetes insipidus due to single pituitary metastasis: case report and literature review. Eur J Oncol. 2011; 16: 55–58.
64. Turaka A, Parsons RB, Buyyounouski MK. Radiation therapy for pituitary metastasis: report of four cases. Tumori. 2012; 98(1): e1–e6, doi: 10.1177/030089161209800127, indexed in Pubmed: 22495726.
65. Uzal MC, Kocak Z, Doganay L, et al. Pituitary metastasis mimicking a macroadenoma from carcinoma of the larynx: a case report. Tumori. 2001; 87(6): 451–454, doi: 10.1177/030089160108700620, indexed in Pubmed: 11989605.
66. Vianello F. Follicular thyroid carcinoma with metastases to the pituitary causing pituitary insufficiency. Thyroid. 2011; 21(8): 921–925, doi: 10.1089/thy.2010.0335, indexed in Pubmed: 21595558.
67. Weber J, Gassel AM, Hoch A, et al. Concomitant renal cell carcinoma with pituitary adenoma. Acta Neurochir (Wien). 2003; 145(3): 227–231, doi: 10.1007/s00701-002-1060-0, indexed in Pubmed: 12632120.
68. Morita A, Meyer FB, Laws ER. Symptomatic pituitary metastases. J Neurosurg. 1998; 89(1): 69–73, doi: 10.3171/jns.1998.89.1.0069, indexed in Pubmed: 9647174.
69. Nishio S, Tsukamoto H, Fukui M, et al. Hypophyseal metastatic hypernephroma mimicking a pituitary adenoma. Case report. Neurosurg Rev. 1992; 15(4): 319–322, doi: 10.1007/BF00257817, indexed in Pubmed: 1480281.
70. Koshiyama H, Ohgaki K, Hida S, et al. Metastatic renal cell carcinoma to the pituitary gland presenting with hypopituitarism. J Endocrinol Invest. 1992; 15(9): 677–681, doi: 10.1007/BF03345815, indexed in Pubmed: 1479150.
71. McCormick PC, Post KD, Kandji AD, et al. Metastatic carcinoma to the pituitary gland. Br J Neurosurg. 1989; 3(1): 71–79, doi: 10.3109/02688698909001028, indexed in Pubmed: 2789715.
72. Eick JJ, Bell KA, Stephan MT, et al. Metastatic renal cell carcinoma presenting as an intrasellar mass on computerized tomography. J Urol. 1985; 134(1): 128–130, doi: 10.1016/s0022-5347(17)47023-6, indexed in Pubmed: 4009805.
73. James RL, Arsenis G, Stoler M, et al. Hypophyseal metastatic renal cell carcinoma and pituitary adenoma. Case report and review of the literature. Am J Med. 1984; 76(2): 337–340, doi: 10.1016/0002-9343(84)90798-8, indexed in Pubmed: 6695956.
74. Buonaguidi R, Ferdeghini M, Faggionato F, et al. Intrasellar metastasis mimicking a pituitary adenoma. Surg Neurol. 1983; 20(5): 373–378, doi: 10.1016/0090-3019(83)90005-8, indexed in Pubmed: 6635925.
75. Anniko M, Lundquist PG, Silfverswärd C, et al. Hypernephroma metastasis in the pituitary gland. A case report. Arch Otorhinolaryngol. 1981; 232(3): 227–232, doi: 10.1007/BF00457446, indexed in Pubmed: 7305726.
76. Weilbaecher C, Patwardhan RV, Fowler M, et al. Metastatic lesions involving the sella: report of three cases and review of the literature. Neurol India. 2004; 52(3): 365–368, indexed in Pubmed: 15472429.
77. Win K, Blocher N, Tester W, et al. Isolated pituitary metastasis from renal cell carcinoma in a horseshoe kidney. Journal of Solid Tumors. 2018; 8(1): 37–41, doi: 10.5430/jst.v8n1p37.
78. Wong AK, Close TW, Wong RH. Osimertinib-induced rapid regression of large metastatic tumor to the pituitary in a patient with lung adenocarcinoma. Surg Neurol Int. 2021; 12: 13, doi: 10.25259/SNI_629_2020, indexed in Pubmed: 33500828.
79. Wu J, Hedges T, Anderson M, et al. Surgical reversal of a subacute complete unilateral visual loss from an ovarian metastasis to the pituitary gland. Neurosurgery. 1992; 31(2): 349–352, doi: 10.1227/00006123-199208000-00022, indexed in Pubmed: 1513441.
80. Yamada SM, Masahira N, Ikawa N, et al. Preoperative surgical approach planning for metastatic pituitary stalk tumor using multimodal fusion imaging in a neuronavigation system–case report. Neurol Med Chir (Tokyo). 2010; 50(3): 259–263, doi: 10.2176/nmc.50.259, indexed in Pubmed: 20339283.
81. Yang C, Zhang H, Zhang S, et al. Oculomotor paralysis, postorbital pain, and hypopituitarism as first presentations of metastatic gastric cancer in the pituitary flourished by internal carotid aneurysm: a case report. Medicine (Baltimore). 2015; 94(50), doi: 10.1097/MD.0000000000002317, indexed in Pubmed: 26683972.
82. Yilmazlar S, Kocaeli H, Cordan T. Sella turcica metastasis from follicular carcinoma of thyroid. Neurol Res. 2004; 26(1): 74–78, doi: 10.1179/016164104773026561, indexed in Pubmed: 14977061.
83. Bell CD, Kovacs K, Horvath E, et al. Papillary carcinoma of thyroid metastatic to the pituitary gland. Arch Pathol Lab Med. 2001; 125(7): 935–938, doi: 10.5858/2001-125-0935-PCOTMT, indexed in Pubmed: 11419981.
84. Masiukiewicz US, Nakchbandi IA, Stewart AF, et al. Papillary thyroid carcinoma metastatic to the pituitary gland. Thyroid. 1999; 9(10): 1023–1027, doi: 10.1089/thy.1999.9.1023, indexed in Pubmed: 10560958.
85. Mayr NA, Yuh WT, Muhonen MG, et al. Pituitary metastases: MR findings. J Comput Assist Tomogr. 1993; 17(3): 432–437, doi: 10.1097/00004728-199305000-00018, indexed in Pubmed: 8491906.
86. Ochiai H, Nakano S, Goya T, et al. Pituitary metastasis of thyroid follicular adenocarcinoma — case report. Neurol Med Chir (Tokyo). 1992; 32(11): 851–853, doi: 10.2176/nmc.32.851, indexed in Pubmed: 1280346.

87. Yoshida M, Ogawa K, Mori Y, et al. Novalis stereotactic radiotherapy improved metastatic pituitary tumor. Intern Med. 2011; 50(7): 789, doi: 10.2169/internalmedicine.50.4949, indexed in Pubmed: 21467721.
88. Zaky M, Compton RA, Alpertunga I, et al. Salivary gland adenocarcinoma metastatic to the pituitary gland. Definitions. 2020, doi: 10.1016/j.amjoto.2021.103153, indexed in Pubmed: 34242881.
89. Zoli M, Mazzatenta D, Faustini-Fustini M, et al. Pituitary metastases: role of surgery. World Neurosurg. 2013; 79(2): 327–330, doi: 10.1016/j.wneu.2012.03.018, indexed in Pubmed: 22480977.
90. Wilkinson BM, Duncan MA, Draytsel DY, et al. Metastatic choroid plexus papilloma presenting as a sellar mass: A case report and literature review. Surg Neurol Int. 2024; 15: 140, doi: 10.25259/SNI_847_2023, indexed in Pubmed: 38742015.
91. Wang H, Zhu M, Yan Y. Neuro-ophthalmological findings of pituitary metastasis: Case series from a single center and review of the literature. Heliyon. 2024; 10(4), doi: 10.1016/j.heliyon.2024.e26027, indexed in Pubmed: 38379980.
92. Suzuki K, Tahara S, Hattori Y, et al. Lung adenocarcinoma metastasis within a pituitary neuroendocrine tumor: a case report with review of literature. Endocr J. 2024; 71(3): 295–303, doi: 10.1507/endocrj.EJ23-0372, indexed in Pubmed: 38171721.
93. Cheng Y, Feng M. A rare case of pituitary metastasis from hepatocellular carcinoma: case report and literature review. Front Oncol. 2023; 13, doi: 10.3389/fonc.2023.1227678, indexed in Pubmed: 37576890.
94. Aung TH, Po YC, Wong WK. Hepatocellular carcinoma with metastasis to the skull base, pituitary gland, sphenoid sinus, and cavernous sinus. Hong Kong Med J. 2002; 8(1): 48–51, indexed in Pubmed: 11861994.
95. Komninos J, Vlassopoulou V, Protopapa D, et al. Tumors metastatic to the pituitary gland: case report and literature review. J Clin Endocrinol Metab. 2004; 89(2): 574–580, doi: 10.1210/jc.2003-030395, indexed in Pubmed: 14764764.
96. Hirsch D, Benbassat CA, Drozd T, et al. Pituitary and bilateral adrenal enlargement: an unusual presentation of hepatocellular carcinoma. J Endocrinol Invest. 2005; 28(5): 454–458, doi: 10.1007/BF03347227, indexed in Pubmed: 16075930.
97. Chen SF, Tsai NW, Lui CC, et al. Hepatocellular carcinoma presenting as nervous system involvement. Eur J Neurol. 2007; 14(4): 408–412, doi: 10.1111/j.1468-1331.2007.01681.x, indexed in Pubmed: 17388989.
98. Moreno-Perez O, Peiró FM, López P, et al. An isolated pituitary metastasis as presentation of a differentiated hepatocellular carcinoma mimicking a nonfunctioning macroadenoma. J Endocrinol Invest. 2007; 30(5): 428–433, doi: 10.1007/BF03346322, indexed in Pubmed: 17598977.
99. Takigawa T, Matsumaru Y, Hayakawa M, et al. Transarterial embolization with use of lipiodol and gelatin sponge for active nasal bleeding from hepatocellular carcinoma metastasis in the pituitary gland. Neurol Med Chir (Tokyo). 2011; 51(8): 592–595, doi: 10.2176/nmc.51.592, indexed in Pubmed: 21869584.
100. Wilson TC, Kirby PA. A 50-year-old man with back pain and a sellar mass. Metastatic hepatocellular carcinoma. Brain Pathol. 2013; 23(3): 365–366, doi: 10.1111/bpa.12053, indexed in Pubmed: 23587145.
101. Tamura T, Kawamura Y, Ikeda K, et al. Hepatocellular carcinoma metastasis to the brain mimicking primary pituitary tumor around the sella turcica. Clin J Gastroenterol. 2013; 6(4): 319–325, doi: 10.1007/s12328-013-0384-z, indexed in Pubmed: 26181737.
102. Shah N, Cavanagh Y, Shaaban H, et al. An unusual initial presentation of hepatocellular carcinoma as a sellar mass. J Nat Sci Biol Med. 2015; 6(2): 471–474, doi: 10.4103/0976-9668.160045, indexed in Pubmed: 26283857.
103. Tanaka T, Hiramatsu K, Nosaka T, et al. Pituitary metastasis of hepatocellular carcinoma presenting with panhypopituitarism: a case report. BMC Cancer. 2015; 15: 863, doi: 10.1186/s12885-015-1831-7, indexed in Pubmed: 26545979.
104. Zhang A, Yuan L, Lin S, et al. Symptomatic pituitary metastasis from hepatocellular carcinoma: a case report and literature review. All Life. 2021; 14(1): 691–698, doi: 10.1023/a:1023994604919, indexed in Pubmed: 12825821.
105. Ambalavanan J, Peravali M, Perry DJ. Rare case of hepatocellular carcinoma metastasising to the pituitary and cavernous sinus causing panhypopituitarism and bilateral ophthalmoplegia. BMJ Case Rep. 2020; 13(10), doi: 10.1136/bcr-2020-236377, indexed in Pubmed: 33109695.
106. Tsutsui T, Hayashi K, Oda M, et al. Pituitary metastasis of salivary gland carcinoma mimicking hypophysitis: A case report and literature review. Int J Surg Case Rep. 2023; 109, doi: 10.1016/j.ijscr.2023.108522, indexed in Pubmed: 37524016.
107. Kawamata T, Harashima S, Kubo O, et al. Intrasellar remote metastasis from adenoid cystic carcinoma of parotid gland: case report. Endocr J. 2006; 53(5): 659–663, doi: 10.1507/endocrj.k05-146, indexed in Pubmed: 16902261.
108. Woo P, Li R. Symptomatic metastasis to the pituitary gland: a report of three cases and review of the literature. J Neurol Disord. 2015; 03(03), doi: 10.4172/2329-6895.1000236.
109. D Hughes J, Retzlaff A, Sims J, et al. Adenoid cystic carcinoma metastatic to the pituitary: a case report and discussion of potential diagnostic value of magnetic resonance elastography in pituitary tumors. World Neurosurg. 2016; 91: 669.e11–669.e14, doi: 10.1016/j.wneu.2016.03.044, indexed in Pubmed: 27018011.
110. Aleyadeh AA, Haddad FH, Al-Omari AA, et al. Pituitary metastasis of follicular thyroid carcinoma: A case report and review of the literature. Rawal Medical Journal. 2012; 37(1): 61–65.
111. Chikani V, Lambie D, Russell A. Pituitary metastases from papillary carcinoma of thyroid: a case report and literature review. Endocrinol Diabetes Metab Case Rep. 2013; 2013, doi: 10.1530/EDM-13-0024, indexed in Pubmed: 24616765.
112. Chrisoulidou A, Pazaitou-Panayiotou K, Flaris N, et al. Pituitary metastasis of follicular thyroid carcinoma. Horm Res. 2004; 61(4): 190–192, doi: 10.1159/000076387, indexed in Pubmed: 14739527.
113. Estrada AJ, Sibley SD, Drake TC. Symptomatic pituitary metastases: two case reports with contrasting clinical presentations. AACE Clin Case Rep. 2019; 5(5): e294–e297, doi: 10.4158/ACCR-2019-0207, indexed in Pubmed: 31967056.
114. Gao H, Wu S, Zhang X, et al. Minimally invasive follicular thyroid carcinoma mimicking pituitary adenoma: a case report. Int J Clin Exp Pathol. 2019; 12(10): 3949–3952, indexed in Pubmed: 31933788.
115. Hirayama M, Ishida A, Inoshita N, et al. Apoplexy in sellar metastasis from papillary thyroid cancer: A case report and literature review. Surg Neurol Int. 2022; 13: 253, doi: 10.25259/SNI_131_2022, indexed in Pubmed: 35855167.
116. Lim W, Lim DS, Chng CL, et al. Thyroid carcinoma with pituitary metastases: 2 case reports and literature review. Case Rep Endocrinol. 2015; 2015, doi: 10.1155/2015/252157, indexed in Pubmed: 25685565.

117. Madronio EB, Lantion-Ang FL. The tale of two tumours: an undiagnosed case of papillary thyroid carcinoma. BMJ Case Rep. 2011, doi: 10.1136/bcr.08.2011.4604, indexed in Pubmed: 22669985.
118. Matyja E, Zieliński G, Witek P, et al. Pituitary metastases from the oncocytic variant of follicular thyroid carcinoma: a case report and diagnostic dilemmas. Folia Neuropathol. 2013; 51(3): 261–268, doi: 10.5114/fn.2013.37711, indexed in Pubmed: 24114644.
119. Meltzer DE, Parnes B, Chai R. Papillary thyroid carcinoma metastasis to the pituitary: A case report. Clin Imaging. 2021; 74: 41–44, doi: 10.1016/j.clinimag.2020.12.030, indexed in Pubmed: 33429145.
120. Muninthorn W, Singhsnaeh A, Auttara-atthakorn A, et al. Pituitary metastasis of papillary thyroid carcinoma:the first case in thailand. J Med Assoc Thai. 2021; 104(Suppl. 5): S140–S146, doi: 10.35755/jmedassocthai.2021.S05.00064.
121. Popławska-Kita A, Wielogórska M, Poplawski Ł, et al. Thyroid carcinoma with atypical metastasis to the pituitary gland and unexpected postmortal diagnosis. Endocrinol Diabetes Metab Case Rep. 2020 [Epub ahead of print], doi: 10.1530/EDM-19-0148, indexed in Pubmed: 32168468.
122. Prodam F, Pagano L, Belcastro S, et al. Pituitary metastases from follicular thyroid carcinoma. Thyroid. 2010; 20(7): 823–830, doi: 10.1089/thy.2009.0256, indexed in Pubmed: 20604687.
123. Simmons JD, Pinson TW, Donnellan KA, et al. A rare case of a 1.5 mm papillary microcarcinoma of the thyroid presenting with pituitary metastasis. Am Surg. 2010; 76(3): 336–338, indexed in Pubmed: 20349670.
124. Simon N, Quyyumi SA, Rothman JG. Follicular thyroid cancer presenting as a sellar mass: case report and review of the literature. Endocr Pract. 2004; 10(1): 62–66, doi: 10.4158/EP.10.1.62, indexed in Pubmed: 15251624.
125. Souza Mota J, de Sá Caldas A, de Araújo Cortês Nascimento AGP, et al. Pituitary Metastasis of Thyroid Carcinoma: A Case Report. Am J Case Rep. 2018; 19: 896–902, doi: 10.12659/AJCR.909523, indexed in Pubmed: 30061553.
126. Zheng H, Chen Y. Pituitary metastasis of thyroid carcinoma: a case report Chinese Journal of endocrinology and metabolism. Chinese Journal of Endocrinology and Metabolism. 2021; 37(12): 481–484.
127. Gariépy C, Champagne PO. Metastatic seeding from a gastrointestinal neoplasia in a pituitary adenoma: a case report and literature review. Cureus. 2023; 15(2), doi: 10.7759/cureus.34676, indexed in Pubmed: 36909111.
128. Rasiah NP, Albakr A, Kosteniuk S, et al. Early and isolated breast cancer metastasis to the pituitary: A case report and systematic review. Surg Neurol Int. 2022; 13: 462, doi: 10.25259/SNI_1053_2021, indexed in Pubmed: 36324911.
129. Öven BB, Demir MK, Çelik S, et al. Isolated pituitary metastasis of renal cell carcinoma: A case report and systematic review of the literature. Curr Med Imaging. 2022; 18(13): 1426–1432, doi : 10.2174/0929866529666220426121245, indexed in Pubmed: 35490330.
130. Beckett DJ, Gama R, Wright J, et al. Renal carcinoma presenting with adrenocortical insufficiency due to a pituitary metastasis. Ann Clin Biochem. 1998; 35 (Pt 4): 542–544, doi: 10.1177/000456329803500410, indexed in Pubmed: 9681058.
131. Pallud J, Nataf F, Roujeau T, et al. Intraventricular haemorrhage from a renal cell carcinoma pituitary metastasis. Acta Neurochir (Wien). 2005; 147(9): 1003–1004; discussion 1004, doi: 10.1007/s00701-005-0591-6, indexed in Pubmed: 16041465.
132. Gołkowski F, Trofimiuk M, Czepko R, et al. Two rare cases of pituitary metastases from breast and kidney cancers. Exp Clin Endocrinol Diabetes. 2007; 115(8): 537–540, doi: 10.1055/s-2007-981456, indexed in Pubmed: 17853340.
133. Shen Z, Yang C, Bao X, et al. Giant sellar metastasis from renal cell carcinoma: A case report and literature review. Medicine (Baltimore). 2018; 97(47), doi: 10.1097/MD.0000000000013376, indexed in Pubmed: 30461658.
134. Xie JS, Donaldson L, Asa S, et al. Pituitary metastasis associated with colon adenocarcinoma mimicking pituitary macroadenoma: a case report and review of the literature. J Neuroophthalmol. 2023; 43(4): e211–e213, doi: 10.1097/WNO.0000000000001429, indexed in Pubmed: 34924528.
135. Saeki N, Murai H, Kubota M, et al. Oedema along the optic tracts due to pituitary metastasis. Br J Neurosurg. 2001; 15(6): 523–526, doi: 10.1080/02688690131719548 2, indexed in Pubmed: 11814008.
136. Noga C, Prayson RA, Kowalski R, et al. Metastatic adenocarcinoma to a pituitary adenoma. Ann Diagn Pathol. 2001; 5(6): 354–360, doi: 10.1053/adpa.2001.29344, indexed in Pubmed: 11745074.
137. Thewjitcharoen Y, Shuangshoti S, Lerdlum S, et al. Colorectal cancer manifesting with metastasis to prolactinoma: report of a case involving symptoms mimicking pituitary apoplexy. Intern Med. 2014; 53(17): 1965–1969, doi: 10.2169/internalmedicine.53.2353, indexed in Pubmed: 25175131.
138. Skulsampaopol J, Klaisuban W, Hansasuta A. Colon metastasis to residual pituitary macroadenoma causing accelerated growth: Case report and review of the literature. Interdisciplinary Neurosurgery. 2017; 8: 26–32, doi: 10.1016/j.inat.2017.01.004.
139. Ozturk MA, Eren OO, Sarikaya B, et al. Pituitary metastasis of colon adenocarcinoma: a rare occurrence. J Gastrointest Cancer. 2014; 45 Suppl 1: 85–87, doi: 10.1007/s12029-013-9554-y, indexed in Pubmed: 24158699.
140. Bostan H, Duger H, Akhanli P, et al. Cushing's syndrome due to adrenocorticotropic hormone-secreting metastatic neuroendocrine tumor of unknown primary origin: a case report and literature review. Hormones (Athens). 2022; 21(1): 147–154, doi: 10.1007/s42000-021-00316-z, indexed in Pubmed: 34478059.
141. Pozzessere D, Zafarana E, Buccoliero A, et al. Gastric cancer metastatic to the pituitary gland: a case report. Tumori. 2007; 93(2): 217–219, doi: 10.1177/030089160709300221, indexed in Pubmed: 17557575.
142. Luu ST, Billing K, Crompton JL, et al. Clinicopathological correlation in pituitary gland metastasis presenting as anterior visual pathway compression. J Clin Neurosci. 2010; 17(6): 790–793, doi: 10.1016/j.jocn.2009.09.044, indexed in Pubmed: 20382025.
143. Takei H, Buckleair L, Goodman JC, et al. Intraoperative cytologic diagnosis of symptomatic carcinoma (pulmonary small cell carcinoma) metastatic to the pituitary gland: a case report. Acta Cytol. 2007; 51(4): 637–641, doi: 10.1159/000325816, indexed in Pubmed: 17718143.
144. Alacacioğlu A, Oztop I, Fidan F, et al. Diabetes insipidus caused by pituitary gland metastasis accompanied by iris metastasis of small cell lung cancer: case presentation and review of the literature. Tumori. 2008; 94(5): 765–768, doi: 10.1177/030089160809400524, indexed in Pubmed: 19112958.
145. Bhatoe HS, Badwal S, Dutta V, et al. Pituitary metastasis from medullary carcinoma of thyroid: case report and review of literature. J Neurooncol. 2008; 89(1): 63–67, doi: 10.1007/s11060-008-9586-5, indexed in Pubmed: 18408891.

146. Fridley J, Adams G, Rao V, et al. Small cell lung cancer metastasis in the pituitary gland presenting with seizures and headache. J Clin Neurosci. 2011; 18(3): 420–422, doi: 10.1016/j.jocn.2010.05.006, indexed in Pubmed: 21237653.
147. Goglia U, Ferone D, Sidoti M, et al. Treatment of a pituitary metastasis from a neuroendocrine tumour: case report and literature review. Pituitary. 2008; 11(1): 93–102, doi: 10.1007/s11102-007-0038-6, indexed in Pubmed: 17458701.
148. Gur C, Lalazar G, Salmon A, et al. Metastatic pancreatic neuroendocrine tumor presenting as a pituitary space occupying lesion: a case report. Pituitary. 2008; 11(3): 293–297, doi: 10.1007/s11102-007-0053-7, indexed in Pubmed: 17638085.
149. Koshimoto Y, Maeda M, Naiki H, et al. MR of pituitary metastasis in a patient with diabetes insipidus. AJNR Am J Neuroradiol. 1995; 16(4 Suppl): 971–974, indexed in Pubmed: 7611088.
150. Marsh JC, Garg S, Wendt JA, et al. Intracranial metastatic disease rarely involves the pituitary: retrospective analysis of 935 metastases in 155 patients and review of the literature. Pituitary. 2010; 13(3): 260–265, doi: 10.1007/s11102-010-0229-4, indexed in Pubmed: 20405323.
151. Peppa M, Papaxoinis G, Xiros N, et al. Panhypopituitarism due to metastases to the hypothalamus and the pituitary resulting from primary breast cancer: a case report and review of the literature. Clin Breast Cancer. 2009; 9(4): E4–E7, doi: 10.3816/CBC.2009.n.047, indexed in Pubmed: 19933072.
152. Riemenschneider MJ, Beseoglu K, Hänggi D, et al. Prostate adenocarcinoma metastasis in the pituitary gland. Arch Neurol. 2009; 66(8): 1036–1037, doi: 10.1001/archneurol.2009.146, indexed in Pubmed: 19667229.
153. Santarpia L, Gagel RF, Sherman SI, et al. Diabetes insipidus and panhypopituitarism due to intrasellar metastasis from medullary thyroid cancer. Head Neck. 2009; 31(3): 419–423, doi: 10.1002/hed.20911, indexed in Pubmed: 18798312.
154. Williams MD, Asa SL, Fuller GN. Medullary thyroid carcinoma metastatic to the pituitary gland: an unusual site of metastasis. Ann Diagn Pathol. 2008; 12(3): 199–203, doi: 10.1016/j.anndiagpath.2006.08.007, indexed in Pubmed: 18486896.
155. Mayson SE, Snyder PJ. Silent pituitary adenomas. Endocrinol Metab Clin North Am. 2015; 44(1): 79–87, doi: 10.1016/j.ecl.2014.11.001, indexed in Pubmed: 25732644.
156. Hall WA, Luciano MG, Doppman JL, et al. Pituitary magnetic resonance imaging in normal human volunteers: occult adenomas in the general population. Ann Intern Med. 1994; 120(10): 817–820, doi: 10.7326/0003-4819-120-10-199405150-00001, indexed in Pubmed: 8154641.
157. Freda PU, Beckers AM, Katznelson L, et al. Pituitary incidentaloma: an endocrine society clinical practice guideline. J Clin Endocrinol Metab. 2011; 96(4): 894–904, doi: 10.1210/jc.2010-1048, indexed in Pubmed: 21474686.
158. Kreitschmann-Andermahr I, Siegel S, Weber Carneiro R, et al. Headache and pituitary disease: a systematic review. Clin Endocrinol (Oxf). 2013; 79(6): 760–769, doi: 10.1111/cen.12314, indexed in Pubmed: 23941570.
159. Molitch ME. Diagnosis and treatment of pituitary adenomas: A review. JAMA. 2017; 317(5): 516–524, doi: 10.1001/jama.2016.19699, indexed in Pubmed: 28170483.
160. Robert CM, Feigenbaum JA, Stern EW. Ocular palsy occurring with pituitary tumors. J Neurosurg. 1973; 38(1): 17–19, doi: 10.3171/jns.1973.38.1.0017, indexed in Pubmed: 4682348.
161. Fleseriu M, Bodach ME, Tumialan LM, et al. Congress of neurological surgeons systematic review and evidence-based guideline for pretreatment endocrine evaluation of patients with nonfunctioning pituitary adenomas. Neurosurgery. 2016; 79(4): E527–E529, doi: 10.1227/NEU.0000000000001387, indexed in Pubmed: 27635959.
162. Molitch ME. Nonfunctioning pituitary tumors. Handb Clin Neurol. 2014; 124: 167–184, doi: 10.1016/B978-0-444-59602-4.00012-5, indexed in Pubmed: 25248587.
163. Sioutos P, Yen V, Arbit E. Pituitary gland metastases. Ann Surg Oncol. 1996; 3(1): 94–99, doi: 10.1007/BF02409058, indexed in Pubmed: 8770309.
164. Schubiger O, Haller D. Metastases to the pituitary — hypothalamic axis. An MR study of 7 symptomatic patients. Neuroradiology. 1992; 34(2): 131–134, doi: 10.1007/BF00588159, indexed in Pubmed: 1603311.
165. Famini P, Maya MM, Melmed S. Pituitary magnetic resonance imaging for sellar and parasellar masses: ten-year experience in 2598 patients. J Clin Endocrinol Metab. 2011; 96(6): 1633–1641, doi: 10.1210/jc.2011-0168, indexed in Pubmed: 21470998.
166. Lithgow K, Siqueira I, Senthil L, et al. Pituitary metastases: presentation and outcomes from a pituitary center over the last decade. Pituitary. 2020; 23(3): 258–265, doi: 10.1007/s11102-020-01034-2, indexed in Pubmed: 32189207.
167. Park M, Lee SK, Choi J, et al. Differentiation between cystic pituitary adenomas and Rathke cleft cysts: a diagnostic model using MRI. AJNR Am J Neuroradiol. 2015; 36(10): 1866–1873, doi: 10.3174/ajnr.A4387, indexed in Pubmed: 26251436.
168. Shimon I, Melmed S. Management of pituitary tumors. Ann Intern Med. 1998; 129(6): 472–483, doi: 10.7326/0003-4819-129-6-199809150-00009, indexed in Pubmed: 9735086.
169. Teears RJ, Silverman EM. Clinicopathologic review of 88 cases of carcinoma metastatic to the pututary gland. Cancer. 1975; 36(1): 216–220, doi: 10.1002/1097-0142(197507)36:1<216::aid-cncr2820360123>3.0.co;2-e, indexed in Pubmed: 1203849.
170. Schill F, Nilsson M, Olsson DS, et al. Pituitary metastases: A nationwide study on current characteristics with special reference to breast cancer. J Clin Endocrinol Metab. 2019; 104(8): 3379–3388, doi: 10.1210/jc.2019-00012, indexed in Pubmed: 30892659.
171. Shimon I. Metastatic spread to the pituitary. Neuroendocrinology. 2020; 110(9-10): 805–808, doi: 10.1159/000506810, indexed in Pubmed: 32101869.
172. Patel KR, Zheng J, Tabar V, et al. Extended survival after surgical resection for pituitary metastases: clinical features, management, and outcomes of metastatic disease to the sella. Oncologist. 2020; 25(5): e789–e797, doi: 10.1634/theoncologist.2019-0520, indexed in Pubmed: 31784491.
173. Ntyonga-Pono MP, Thomopoulos P, Luton JP. Pituitary metastases. 3 cases. Presse Med. 1999; 28(29): 1567–1571, indexed in Pubmed: 10544705.
174. Branch CL, Laws ER. Metastatic tumors of the sella turcica masquerading as primary pituitary tumors. J Clin Endocrinol Metab. 1987; 65(3): 469–474, doi: 10.1210/jcem-65-3-469, indexed in Pubmed: 3624409.
175. Ju H, Zhou J, Pan Yu, et al. Evaluation of pituitary uptake incidentally identified on 18F-FDG PET/CT scan. Oncotarget. 2017; 8(33): 55544–55549, doi: 10.18632/oncotarget.15417, indexed in Pubmed: 28903440.