Pathology – Research and Practice 209 (2013) 155–160

Contents lists available at SciVerse ScienceDirect

Pathology – Research and Practice

journal homepage: www.elsevier.com/locate/prp

Original article

"Leiomyomatoid angiomatous neuroendocrine tumor" (LANT) of the pituitary reflects idiosyncratic angiogenesis in adenomas of the gonadotroph cell lineage

Christian Schürch[a], Michèle Birrer[a], Isabelle Estella[a], Andreas Kappeler[b], Ekkehard Hewer[a,c], Istvan Vajtai[a,c,*]

[a] Department of Clinical Pathology, Institute of Pathology, University of Bern, Switzerland
[b] Laboratory of Diagnostic Immunohistochemistry, Institute of Pathology, University of Bern, Switzerland
[c] Section of Neuropathology, Department of Clinical Pathology, Institute of Pathology, University of Bern, Switzerland

ARTICLE INFO

Article history:
Received 4 October 2012
Received in revised form
23 December 2012
Accepted 10 January 2013

Keywords:
LANT
Pituitary adenoma
Maladaptive angiogenesis
Vascular malformation

ABSTRACT

Based on a single-case observation, the descriptive label "leiomyomatoid angiomatous neuroendocrine tumor" (LANT) has been tentatively applied to what was perceived as a possible novel type of dual-lineage pituitary neoplasm with biphasic architecture. We report on two additional examples of an analogous phenomenon encountered in male patients, aged 59 years (Case 1) and 91 years (Case 2). Both tumors were intra- and suprasellar masses, measuring 5.6 cm × 4.4 cm × 3.4 cm, and 2.7 cm × 2 cm × 1.7 cm, respectively. Histologically, Case 1 was an FSH-cell adenoma interwoven by vascularized connective tissue septa that tended to exhibit incremental stages of adventitial overgrowth. The epithelial component of Case 2 corresponded to an LH-cell adenoma, and lay partitioned by a maze of paucicellular to hyalinized vascular axes. Irrespective of architectural variations, perivascular spindle cells exhibited immunopositivity for vimentin, muscular actin, and smooth muscle actin. Conversely, negative results were obtained for CD34, EMA, S100 protein, GFAP, and TTF-1. Ultrastructural study failed to reveal metaplastic cell forms involving transitional features between adenohypophyseal–epithelial and mesenchymal–contractile phenotype. We propose that LANT be regarded as a peculiar reflection of maladaptive angiogenesis in some pituitary adenomas, rather than a genuine hybrid neoplasm. While no mechanistic clue is forthcoming to account for this distinctive pattern, hemodynamic strain through direct arterial – rather than portal – supply of the adenoma's capillary bed may be one such explanatory factor. The apparent predilection of the LANT pattern for macroadenomas of the gonadotroph cell lineage remains unexplained.

Introduction

In the decade leading up to the 2007 World Health Organization (WHO) Classification of Tumours of the Central Nervous System, awareness of non-adenomatous pituitary neoplasms spawned a multiplication of candidate lesions [4,7,13,15,16] along with a refinement of individual categories – a pursuit ultimately acknowledged by the introduction of two novel entities: spindle cell oncocytoma and pituicytoma [1,17,24].

A fitting product of the *Zeitgeist*, "leiomyomatoid angiomatous neuroendocrine tumor" (LANT) has been proposed as a unique form of dual-lineage neoplasm with conspicuous dimorphism of its neuroendocrine and mesenchymal components [21].

Since its introduction in 2006, however, the reproducibility of the LANT paradigm has been addressed by only three reports – yet with contradictory conclusions. Sakashita et al. [18] and Jones et al. [8] subsumed each an arguably evocative – if not identical – uterine tumor under the LANT label, whereas Sato et al. observed a pituitary "macroadenoma with hemangiomatous stroma" – which they nevertheless claimed to be unrelated to LANT [19].

In the following, we are sharing our experience with two additional sellar lesions that are felt to essentially replicate all salient features of the original LANT phenomenon. Individually exhibiting what may be best regarded as different stages of evolution of the same process, these findings suggest that LANT probably represents a peculiar pattern of pituitary adenoma angiogenesis, rather than a genuine example of epithelial–mesenchymal transition.

Case reports

Clinical histories

Case 1

A 59-year-old male patient sought medical attention for severe adynamia and progressive bitemporal visual field restriction.

* Corresponding author at: Section of Neuropathology, Institute of Pathology, University of Bern, Murtenstrasse 31, P.O. Box 62, 3010 Bern, Switzerland.
Tel.: +41 31 632 32 10; fax: +41 31 632 99 38.
E-mail address: istvanvajtai@yahoo.com (I. Vajtai).

0344-0338/$ – see front matter © 2013 Elsevier GmbH. All rights reserved.
http://dx.doi.org/10.1016/j.prp.2013.01.003

Magnetic resonance imaging (MRI) of the skull base revealed a voluminous sellar mass of 5.6 cm × 4.4 cm × 3.4 cm with invasion of the sphenoid sinus and suprasellar extension (Fig. 1A). Endocrinologic testing revealed severe panhypopituitarism. In the face of threatening irreversible damage to the optic nerves, no pharmacotherapeutic tumor reduction was attempted, and the patient underwent transphenoidal surgery. Complete resection failed due to the lesion's unusually firm texture and propensity to bleed – however, numerous biopsy fragments totalling 4 cm × 3 cm × 0.5 cm could be obtained. The patient underwent external beam radiotherapy to the tumor bed with 54 Gy, and is alive with stable residual disease 5 years postoperatively.

Case 2

A 91-year-old male with a longstanding history of coronary heart disease and chronic renal failure has died within days after having suffered an unwitnessed fall in his home. Upon admission, cranial computed tomography (CT) revealed multifocal apoplectiform intracerebral hemorrhages. In addition, a pituitary tumor of 2.7 cm × 2 cm × 1.7 cm was documented as an incidental finding (Fig. 2A). The patient's anamnesis did not include any specific reference to either endocrine dysfunction or previous therapeutic measures directed at the pituitary. Neuropathologic autopsy indicated a combination of cerebral amyloid angiopathy and hypertensive changes to be the most likely cause of the bleeding. Protruding from the sella turcica, a firm, white-to-tan mass with finely bosselated surface corresponded to the *ante mortem* radiological finding (Fig. 2B).

Materials and methods

Processing for histology, immunohistochemistry, and electron microscopy was done according to standard protocols established in our laboratory, the details of which have been documented previously [21]. In addition to the panel of antibodies that had been used for the study of the initial LANT case, immunostaining for thyroid transcription factor 1 – TTF-1 (clone SPT24; Leica Biosystems, Newcastle-upon-Tyne, UK) was performed as well.

Pathologic findings

Case 1

Microscopically, the tumor consisted of a disorderly amalgam of chromophobic adenoma and vascular sprouts at varying stages of maturation (Fig. 2B and C). These ranged from tortuous capillaries – including some nearly glomeruloid tufts – through adventitial-rich small-caliber vessels of indeterminate type, to sinusoidal channels encircled by a prominent sheath of spindle cells. Of limited extent, the latter portions were perceived as a biphasic epithelial–mesenchymal proliferation. Throughout this continuum, perivascular spindle cells were intensely immunoreactive for vimentin, and tended to coexpress muscular actin and SMA (Fig. 2D–F). Conversely, staining for CD34 was limited to endothelial cells (Fig. 2G), whereas S100 protein, GFAP, EMA, and TTF-1 yielded each negative results (not shown). On the other hand, the epithelial moiety exhibited a conventional gonadotroph immunophenotype, including positivity for FSH and α-subunit on a background of generalized staining for synaptophysin and chromogranin A (Fig. 2H–J). Ultrastructurally, there was clear-cut separation of organelles reflecting either neuroendocrine or contractile properties in the adenomatous and leiomyomatous components, respectively (Fig. 1K–M). No intermediate cell forms could be detected.

Case 2

In contrast to the intuitively dynamic (evolving) morphology of Case 1, this tumor was composed of an inert-looking maze of paucicellular to sclerotic connective tissue septa wherein nests and strands of adenomatous epithelium lay entrapped (Fig. 2C–F). These exhibited a gonadotrophic phenotype, including immunoexpression of synaptophysin, chromogranin A, LH, α-subunit as well as CAM5.2 (Fig. 2G–J). Stromal spindle cells, on the other hand, were felt to replicate the immunoprofile of their counterparts in Case 1 – although their cytoplasm often tended to vanish between tightly apposed layers of collagen (Fig. 2K and L). Study of serial whole-mount sections derived from this specimen also permitted the tumor's relationship to the adjacent pituitary gland to be appreciated: no continuity to either neurohypophysis or the cavernous sinus was apparent (Fig. 2M). Although preservation of ultrastructural detail was rather poor, electron microscopy nevertheless permitted unambiguous discrimination between epithelial and mesenchymal elements (Fig. 2N–P).

In both cases, we issued a diagnosis of gonadotroph cell adenoma, including the individual lesions' immunophenotype as appropriate, along with a descriptive comment on their respective vascular–mesenchymal component.

Recurrence of the index case

The eponymous "LANT" described by our group [21] recurred twice – at 2-year and 4-year intervals, respectively – following our initial study of the tumor. Our microscopic review of the first recurrence indicated its morphology to have remained unchanged (Fig. 3). The lesion's immunophenotype, however, was conspicuous for the presence of faint focal reactivity for FSH – a finding not present in the primary specimen. The histologic diagnosis of the second recurrence was established in an external institution (see Acknowledgements), and reportedly yielded an identical result.

Discussion

We observed two pituitary adenomas with unconventional morphology, characterized by progressive encroachment of exuberant vascular-derived stromal elements upon the neurosecretory parenchyma. We regard these cases as additional examples of what was originally described as LANT – and provisionally speculated to represent a dual-lineage or metaplastic lesion [21]. The present cases are felt to be complementing the initial observation in two significant respects.

First, the epithelial component of both tumors was unambiguously ascribable to the gonadotroph cell adenoma category with immunoexpression of FSH in Case 1, and LH in Case 2. In retrospect, these findings are also apt to corroborating the earlier impression that the endocrine moiety in the index LANT case might actually correspond to an oligophenotypic form of gonadotroph cell adenoma (*i.e.*, null cell adenoma) [9].

Second, the index LANT case obviously reflected a static *aperçu* of the tumor's natural history, conveying the impression of a rather invariable – if highly unusual – vasculogenic stroma. The intra- and interspecimen shifts in the composition of the stromal elements observed in the present cases suggest, instead, an evolutive process. Specifically, the appearance of randomly spaced and individually variable capillaries, as observed in Case 1, is likely to pertain to an early phase of this sequence. Indeed, the emerging chaotic pattern is one of pronounced "microvascular structural entropy" – a distinctive hallmark of pituitary adenomas [23]. Conversely, the overlapping morphology of the hyalinized septa of Case 2 and that of the plump, cell-depleted vascular axes in some areas of Case 1 lends itself to being viewed as an advanced, possibly involutive stage.

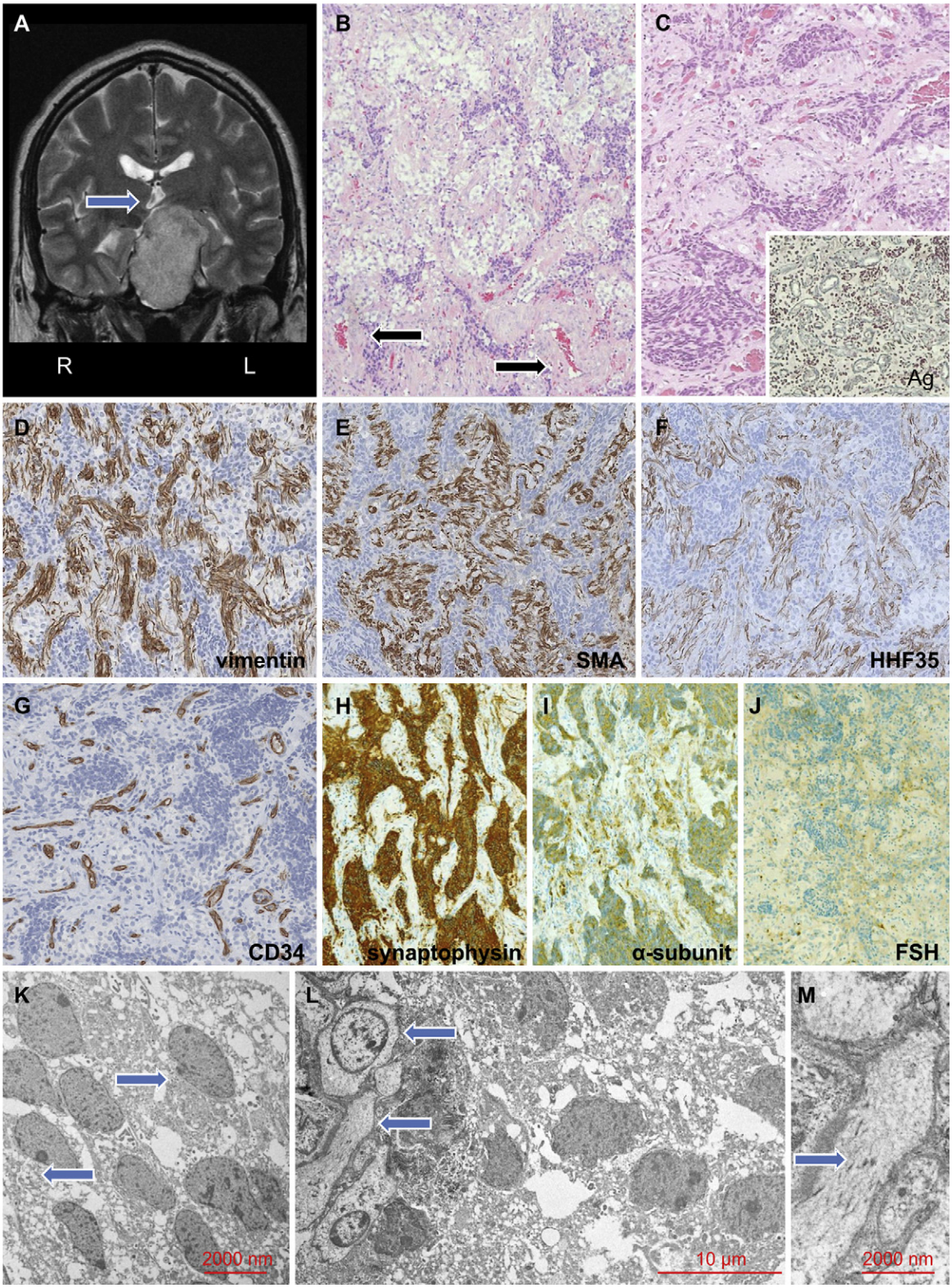

Fig. 1. Radiologic presentation, histology, immunophenotype, and ultrastructure of Case 1. (A) On T_2 weighted frontal MRI scan, the tumor appears as a moderately hyperintense mass protruding upwards from the ballooned sella to obliterate the chiasmatic cistern and distort the third ventricle (arrow). (B) Transition between parenchyma-rich, adenomatous component with chromophobe characteristics (upper half) and stromal-predominant "LANT" pattern (lower half). Note convergence of connective tissue septa upon vessel walls (arrows). (C) Biphasic architecture involving nests or strands of nondescript epithelial cells and an encroaching vasculogenic stroma. Exuberant vascular proliferation is readily visualized by reticulin staining (inset). (D–G) Roughly overlapping staining patterns for vimentin, smooth muscular as well as muscular actin indicate the entire breadth of the septa to include a significant proportion of leiomyomatous elements, whereas corresponding central vessels are highlighted by the endohelial marker CD34. (H–J) Rudimentary gonadotroph phenotype of the adenomatous component is evidenced by coexpression of synaptophysin and α-subunit, as well as faint immunolabeling for FSH in a minority of tumor cells. (K) The endocrine moiety consists of slightly polarized epithelial cells, the cytoplasm of which tends to be obliterated by mitochondria (oncocytic change), whereas neurosecretory granules are distinctly scant (arrows). (L) Interface of adenoma and leiomyomatous stromal elements (arrows). Note abrupt biphasic segregation of these populations with no evidence of intervening cells of transitional character. (M) Myofibrils within the cytoplasm of a smooth muscle cell are readily appreciated (arrow). Microphotographs A–C represent H.E. stained slides. Original magnifications: B and C 100×; D–J 150×; scales for J–L are indicated by bars.

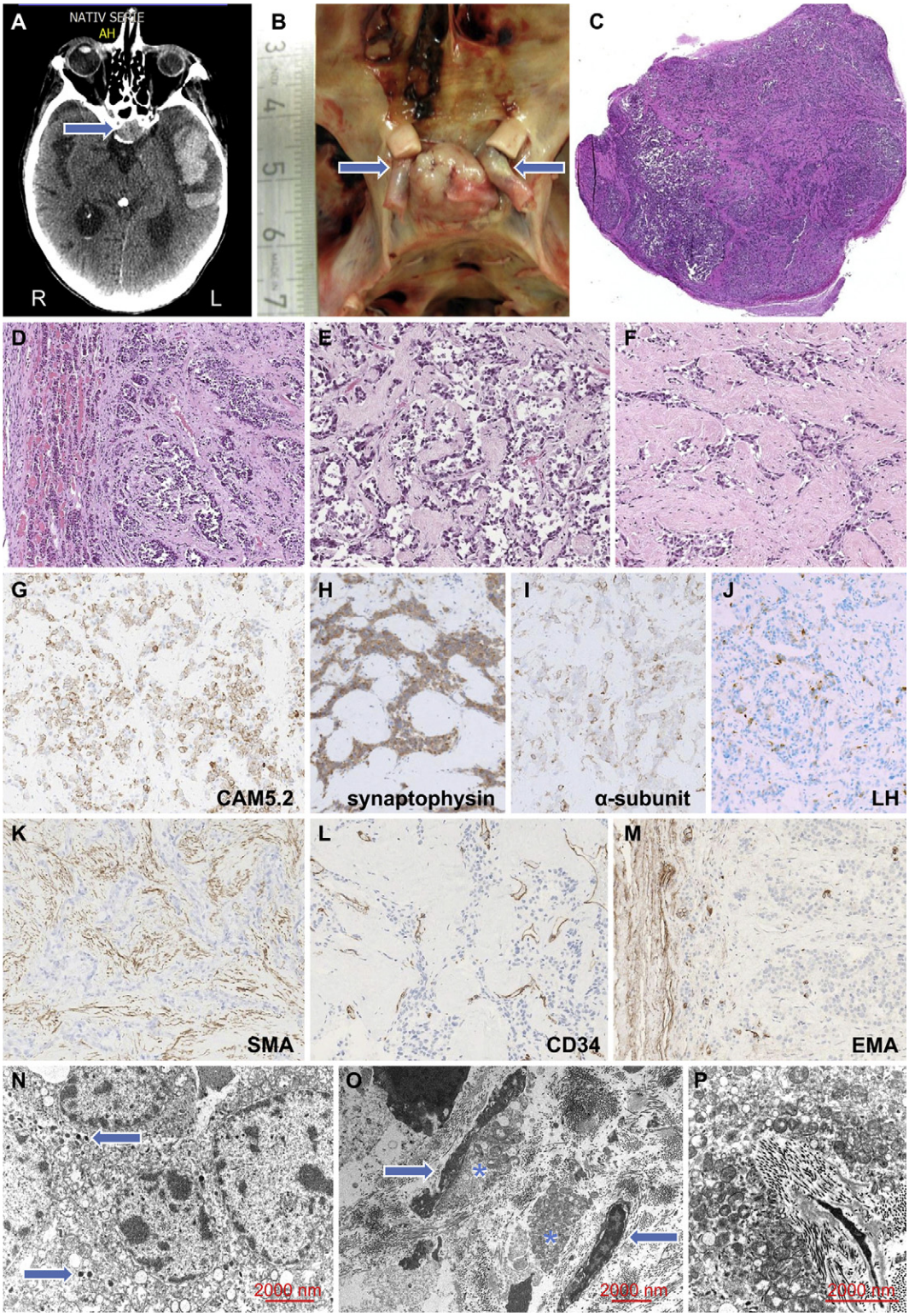

Fig. 2. Gross appearance, histology, immunophenotype, and ultrastructure of Case 2. (A) An accidental finding on axial CT scan; the sellar region appears obliterated by a discrete, isointense, globular mass (arrow). "Atypical" intracerebral hemorrhage is seen in the left temporal cortex. (B) *In situ* photograph of cranial base during autopsy to show bosselated nodule protruding from the sella turcica, and slightly dislocating the intracranial segments of both carotid arteries (arrows). (C) Whole-mount section of tumor reveals a hypocellular maze of sclerotic septa as the most salient feature of this lesion. Crescent-like remnant of the neurohypophysis is seen near the lower margin of the photograph. (D) Microphotograph of tumor/pituitary interface reveals organoid – if relatively abrupt – transition from native parenchyma to LANT with no apparent encapsulation. (E and F) As in other lesions of this type, the relative proportions of adenomatous and stromal elements tend to vary from parenchyma-rich to paucicellular and densely sclerotic. (G–L) The tumor's immunophenotype basically replicates the findings in Case 1, corresponding to a rudimentarily differentiated gonadotroph cell adenoma entrapped in a lattice of exuberant adventitial-derived connective tissue. (M) EMA-stained section from the tumor's periphery highlights arachnoidal cells within the pituitary capsule – to show that intralesional septa are not of meningothelial origin. (N) Adenoma cells exhibit a poorly differentiated set of organelles, mostly consisting of mitochondria as well as few secretory granules (arrow). (O and P) Distorted cytoplasm of two adenoma cells (asterisks) encased by a pair of nondescript mesenchymal spindle cells (arrows) as well as collagen fibers. Unambiguous ultrastructural hallmarks of smooth muscle differentiation could not be identified in this sample. Microphotographs C–F represent H.E. stained slides. Original magnifications: C 10×; D and M 100×; G–L 150×; scales for N–P are indicated by bars.

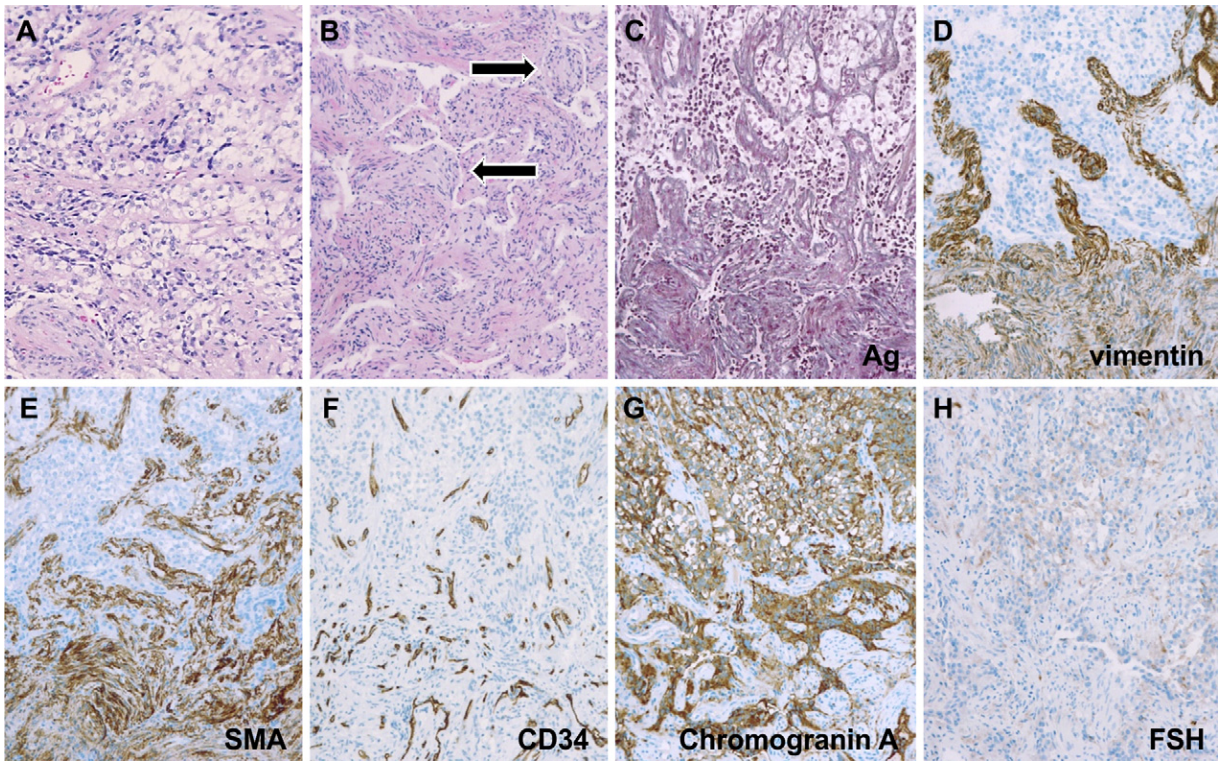

Fig. 3. Histology and immunophenotype of first recurrence of the index case. (A) The primary tumor's conspicuous biphasic architectural motive is being perpetuated to produce continuous shifts from (A) relatively parenchymal-rich to (B) stromal-dominant areas. Note multilayered adventitial cuffs (arrows). (C) Reticulin stain of parenchymal–stromal transition zone reveals massive increase in connective tissue fibers. (D–F) On sections from the same area, roughly overlapping immunoreactivity for (D) vimentin and (E) smooth muscle actin indicates leiomyomatous phenotype of most cells within septa, each of the latter being centered on a (F) vascular axis. (G and H) The neurosecretory character of the epithelial moiety is confirmed by labeling for chromogranin A; whereas faint immunoreactivity for FSH indicates rudimentary gonadotrophic differentiation. Microphotographs A and B represent H.E. stained slides. Original magnifications: A 200×; B 150×; C–H 125×.

At any point of its morphogenesis, the adventitial overgrowth was felt to be driven by a population of spindle cells with rudimentary smooth muscular properties as evidenced by immunohistochemistry and ultrastructure. Problematic from the outset, the histogenesis of the latter had been initially speculated to possibly relate to folliculo-stellate cells (FSCs). In the meantime, spindle cell oncocytoma – a neoplastic derivative of FSCs – has indeed been shown to occasionally transdifferentiate into endocrine epithelial-like follicular arrays, a phenomenon that may suggest a minimalistic blueprint for LANT's dimorphism [22]. Negative immunostaining for TTF-1, however, does not support that line of thought [11]. Furthermore, the whole-mount sections obtained from Case 2 clearly indicated the tumor not to originate from the smooth muscular sphincters of the neurohypophysial gomitoli [21]. Conversely, lack of EMA immunostaining within the vessel-bearing septa argues against a meningoangiomatosis-like ingrowth from the pituitary capsule.

A systematic review of differential diagnoses has been provided in the original report on LANT, and will not be addressed here.

Based on the above, "LANT" may be best conceived as a rare pattern of angiogenesis in some pituitary adenomas, rather than a genuine hybrid/metaplastic neoplasm.

Sakashita et al. proposed in 2008 that their case of a myometrial tumor resected from a 45-year-old patient might represent an equivalent of LANT outside its native habitat in the sellar region [18]. Richly vascularized by capillary to venous type vessels, that lesion involved angiocentric arrays of "stromal cells" with hybrid smooth muscular/neuroendocrine properties. Specifically, the cells' immunophenotype included a unique combination of positivities for vimentin, desmin, SMA, S100 protein, NCAM, and chromogranin A. Bidirectional differentiation was also documented by electron microscopic visualization of coexisting neurosecretory granules alongside a contractile apparatus within the same cell. Of late, Jones et al. reported on an additional example of not otherwise classifiable mixed leiomyomatous–endocrine tumor of the uterus with similar features [8].

We are inclined to regard these findings as being different from what our additional experience revealed about LANT of the pituitary: (i) the endocrine component of all three cases fulfilled criteria of pituitary gonadotroph cell adenoma; (ii) several traits of the immunoprofile of Sakashita et al. case are – individually or in combination – not compatible with any type of pituitary adenoma; (iii) neither the epithelial nor the stromal cell population in our three cases exhibited bidirectional differentiation.

Therefore, while "LANT" of the pituitary is ultimately amenable to a reductionist understanding as a complex variant of an already existing entity, the lesions described by Sakashita et al. and Jones et al. arguably defy such labeling – and may indeed represent a novel pathology.

Conversely, the "pituitary macroadenoma with hemangiomatous stroma" recently reported by Sato et al. does lend itself to being viewed as a *bona fide* independent confirmation of the LANT phenomenon [19]. Surgically resected from a 55-year-old male, that sellar lesion of 2.2 cm diameter comprised a biphasic alternance of a neuroendocrine parenchyma that was immunopositive for cytokeratin AE1/AE3, chromogranin A, and α-subunit, with a markedly vascularized stroma. The latter is being described as one composed of "collagen fibers" rather than smooth muscle cells – whereby the authors conclude that "these findings were not compatible with LANT", and that their case might possibly represent yet "another type of pituitary adenoma with biphasic features". We point out, instead, the resemblance of these vascular septa depleted of smooth

muscle cells to those observed in our Case 2: these, in turn, tended to merge into more leiomyomatous foci – supporting the dynamic character of the LANT-type vasculature.

We are unable to offer an explanation for the LANT pattern of vascularization that might be mechanistically extrapolated from descriptive evidence on pituitary adenoma angiogenesis. The issue is indeed compounded *a priori* by the apparent lack of any consistent link between quantifiable parameters of tumor vascularity and either hormonal phenotype, size, or invasiveness in conventional adenomas [3,12]. Counterintuitively enough, microvessel density of pituitary adenomas is actually inferior to that of the normal adenohypophysis [12,25]. The same holds true for the expression of most angiogenic factors by adenoma cells.

Exceptionally, pituitary adenoma vascularization will proceed through – or be complemented by – angiogenic mimicry in the form of intratumoral peliosis [14]. Our cases, however, did not exhibit any such feature. Along the same line, there was no evidence of ancient intratumoral hemorrhage, the organization of which might have produced an angioma-like pattern through papillary endothelial hyperplasia [10].

By analogy to the growth of "slow-flow" vascular malformations in other locations, we also entertained the hypothesis that inappropriately elevated blood pressure within an otherwise conventional adenoma's microcirculation might have promoted compensatory arteriolization of the capillary bed. In effect, while most pituitary adenomas tend to be fed by portal (tubero-infundibular) blood, some receive, instead, direct arterial supply from the internal carotid *via* the inferior hypophysial artery and/or capsular vessels [5,6]. Since portal-derived capillaries are morphologically indistinguishable from those of arterial origin, the extent to which either source contributes to an individual adenoma's vascularization cannot eventually be determined by conventional histology. It is tempting to speculate that in some scenarios of progressive vascular recruitment, shunt-type hyperperfusion of the preexisting capillary bed may arise – eliciting compensatory adventitial smooth muscle hyperplasia. On the other hand, vascular remodeling may not proceed adequately due to failure of pressure-passive intratumoral veins to regress – thereby contributing an obliterative, varicose-like component.

Unfortunately, the repeated recurrence of our index case with largely conserved morphology does not support the above speculation.

In sum, while LANT may henceforth be regarded as a distinctive pituitary adenoma variant – if not an entity – its pathogenesis remains elusive.

The alternative of a chance encounter of pituitary adenoma and a vascular neoplasm be only mentioned for the sake of completeness. In fact, the sole vessel-forming tumors to occur with more than anecdotal probability in the sella are cavernous hemangioma and hemangioblastoma – none of which is likely to be misconstrued as LANT-type vascular pattern [2,20]. Postulating a collision-type pathology also fails to address the intriguing predilection of the LANT phenomenon for adenomas of the gonadotroph cell lineage.

Acknowledgements

We wish to thank Mrs. Micaela Güdel, Christine Steffen, and Ellen Lanz for the expert handling of the immunohistochemical reactions referred to in this report. The histologic diagnosis of the index case has been independently confirmed by Dr. Ingeborg Fischer and Prof. Adriano Aguzzi (Institute of Neuropathology, University Hospital Zürich, Switzerland). The neuroimaging documentation has been kindly provided by Professor Gerhard Schroth (Department of Neuroradiology, University Hospital "Inselspital" Bern, Switzerland). Referencing has been assisted by Mrs. Sibylle Graf and Irène Marconi-Geiser. Special thanks are owed to Prof. Werner Paulus (Institute of Neuropathology, University Hospital Münster, Germany) for stimulating comments on the manuscript draft.

References

[1] D.J. Brat, B.W. Scheithauer, S.M. Staugaitis, R.N. Holtzman, S. Morgello, P.C. Burger, Pituicytoma: a distinctive low-grade glioma of the neurohypophysis, Am. J. Surg. Pathol. 24 (2000) 362–368.
[2] C.S. Cobbs, C.B. Wilson, Intrasellar cavernous hemangioma. Case report, J. Neurosurg. 94 (2001) 520–522.
[3] A.B. Cohen, S. Lessell, Angiogenesis in pituitary tumors, Semin. Ophthalmol. 24 (2009) 185–189.
[4] A. Giustina, M. Gola, M. Doga, E.A. Rosei, Primary lymphoma of the pituitary: an emerging clinical entity, J. Clin. Endocrinol. Metab. 86 (2001) 4567–4575.
[5] W. Gorczyca, J. Hardy, Arterial supply of the human anterior pituitary gland, Neurosurgery 20 (1987) 369–378.
[6] W. Gorczyca, J. Hardy, Microadenomas of the human pituitary and their vascularization, Neurosurgery 22 (1988) 1–6.
[7] E. Horvath, K. Kovacs, B.W. Scheithauer, R.V. Lloyd, H.S. Smyth, Pituitary adenoma with neuronal choristoma (PANCH): composite lesion or lineage infidelity? Ultrastruct. Pathol. 18 (1994) 565–574.
[8] K.L. Jones, P.B. Tripathi, S.A. Srivastava, A.L. Beavis, K. Matsuo, M.N. Moffitt, A. Maliglig, Y.G. Lin, Leiomyomatoid angiomatous neuroendocrine tumor of the uterine myometrium with synchronous renal leiomyosarcoma: case report and review of the literature, Int. Cancer Conf. J. 1 (2012) 243–250.
[9] K. Kovacs, The 2004 WHO classification of pituitary tumors: comments, Acta Neuropathol. 111 (2006) 62–63.
[10] R.A. Kristof, D. Van Roost, H.K. Wolf, J. Schramm, Intravascular papillary endothelial hyperplasia of the sellar region. Report of three cases and review of the literature, Neurosurgery 86 (1997) 558–563.
[11] E.B. Lee, T. Tihan, B.W. Scheithauer, P.J. Zhang, N.K. Gonatas, Thyroid transcription factor 1 expression in sellar tumors: a histogenetic marker? J. Neuropathol. Exp. Neurol. 68 (2009) 482–488.
[12] R.V. Lloyd, S. Vidal, E. Horvath, K. Kovacs, B.W. Scheithauer, Angiogenesis in normal and neoplastic pituitary tissue, Microsc. Res. Tech. 60 (2003) 244–250.
[13] L. Mariani, B. Schaller, J. Weis, C. Ozdoba, R.W. Seiler, Esthesioneuroblastoma of the pituitary gland: a clinicopathologic entity? Case report and review of the literature, J. Neurosurg. 101 (2004) 1049–1052.
[14] S. Mohammed, L.V. Syro, B.W. Scheithauer, A. Abad, H. Uribe, F. Rotondo, E. Horvath, M. Cusimano, K. Kovacs, Pituitary adenoma with peliosis: a report of two cases, Endocr. Pathol. 20 (2009) 41–45.
[15] K. Mukhida, S. Asa, F. Gentili, P. Shannon, Ependymoma of the pituitary fossa. Case report and review of the literature, J. Neurosurg. 105 (2006) 616–620.
[16] W. Paulus, J. Honegger, K. Keyvani, R. Fahlbusch, Xanthogranuloma of the sellar region: a clinicopathologic entity different from adamantinomatous craniopharyngioma, Acta Neuropathol. 97 (1999) 377–382.
[17] F. Roncaroli, B.W. Scheithauer, G. Cenacchi, E. Horvath, K. Kovacs, R.V. Lloyd, P. Abell-Aleff, M. Santi, A.J. Yates, Spindle cell oncocytoma of the adenohypophysis: a tumor of folliculostellate cells? Am. J. Surg. Pathol. 26 (2002) 1048–1055.
[18] N. Sakashita, M. Yamada, T. Nakagawa, H. Yamasaki, M. Takeya, A leiomyomatoid angiomatous neuroendocrine tumor of the myometrium: case study with ultrastructural analysis, Hum. Pathol. 39 (2008) 788–792.
[19] H. Sato, H. Takahashi, G. Kanai, T. Kakuta, J. Itoh, C. Inomoto, R.Y. Osamura, Syndrome of inappropriate secretion of antidiuretic hormone caused by pituitary macroadenoma with hemangiomatous stroma, Tokai J. Exp. Clin. Med. 36 (2011) 128–133.
[20] R.T. Schär, I. Vajtai, R. Sahli, R.W. Seiler, Manifestation of a sellar hemangioblastoma due to pituitary apoplexy: a case report, J. Med. Case Reports 5 (2011) 496.
[21] I. Vajtai, R. Sahli, A. Kappeler, E.R. Christ, R.W. Seiler, Leiomyomatoid angiomatous neuroendocrine tumor (LANT) of the pituitary: a distinctive biphasic neoplasm with primitive secretory phenotype and smooth muscle-rich stroma, Acta Neuropathol. 111 (2006) 278–283.
[22] I. Vajtai, J. Beck, A. Kappeler, E. Hewer, Spindle cell oncocytoma of the pituitary gland with follicle-like component: organotypic differentiation to support its origin from folliculo-stellate cells, Acta Neuropathol. 122 (2011) 253–258.
[23] S. Vidal, E. Horvath, K. Kovacs, R.V. Lloyd, B.W. Scheithauer, Microvascular structural entropy: a novel approach to assess angiogenesis in pituitary tumors, Endocr. Pathol. 14 (2003) 239–248.
[24] D.N. Louis, H. Ohgaki, O.D. Wiestler, W.K. Cavenee, P.C. Burger, A. Jouvet, B.W. Scheithauer, P. Kleihues, The 2007 WHO classification of tumours of the central nervous system, Acta Neuropathol. 114 (2007) 97–109.
[25] S. Yamada, K. Takada, Angiogenesis in pituitary adenomas, Microsc. Res. Tech. 60 (2003) 236–243.