Pancreatic endocrine tumour with cytoplasmic keratin whorls. Is the term ‘‘rhabdoid’’ appropriate?

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A 50 year old woman presented with acute abdominal pain accompanied by nausea and vomiting and was found to have a mass in the head of the pancreas by imaging. The clinical impression was of a pancreatic carcinoma and a Whipple’s procedure was performed. Microscopic examination of the tumour showed it to be a low grade neuroendocrine carcinoma arranged in a tubulocinar or tubulopapillary pattern, and composed of cells harbouring very prominent intracytoplasmic inclusions. These inclusions varied in appearance from being pale pink and hyaline in quality to more eosinophilic and globular causing displacement of the nucleus. Ultrastructural examination showed typical paranuclear aggregates of intermediate filaments. Inclusions of this type have been described previously as ‘‘signet ring like’’ and ‘‘rhabdoid’’. It was felt that the inclusions more closely resemble the fibrous bodies that are seen in pituitary adenomas. In addition, it is suggested that both signet ring and rhabdoid are not appropriate because they do not reflect histogenesis and are not necessarily reflective of tumour biology. It is suggested that the term ‘‘cytokeratin aggresomes’’ should be used to describe this distinctive phenotype.

The cytoplasmic hyaline globules encountered in our patient and the other so called ‘‘rhabdoid’’ pancreatic endocrine tumours were attributable to the accumulation of whorls of intermediate keratin filaments in a characteristic paranuclear or juxtanuclear location. These inclusions are analogous to keratin positive structures or ‘‘fibrous bodies’’ that are encountered in another endocrine gland, the pituitary. This should not be confused with Crooke’s hyaline, which are aggregates of intermediate filaments that are dispersed throughout the cytoplasm and are not found as a characteristic paranuclear whorl or ball. The spectrum of morphological changes induced by fibrous bodies within the cytoplasm of endocrine neoplasms ranges from normal by light microscopy, to hyaline weakly eosinophilic inclusions, to deeply acidophilic/eosinophilic inclusions occupying most of the cytoplasm and displacing the nucleus eccentrically (the typical ‘‘rhabdoid’’ phenotype). Intracytoplasmic inclusions composed of aggregates of juxtanuclear cytokeratin immunoreactive intermediate filaments have been identified in several tumours of endocrine and related cells. Although the pathogenetic trigger in each different tumour may vary and remain conjectural at this juncture, juxtanuclear aggregates of intermediate cytokeratin filaments appear to be the common thread in most instances accounting for a similar morphological appearance in a variety of different tumours.

The purpose of our report is to highlight an example of a pancreatic endocrine tumour with an unusual morphological appearance, emphasise the spectrum of changes that can be obtained with cytoplasmic, juxtanuclear intermediate filament aggregation, and also to suggest that the term ‘‘rhabdoid’’ is not an apt description and should be replaced by the descriptive phrase ‘‘cytokeratin aggresomes’’ for the moment, until the exact clinical and biological relevance of this morphological appearance is better understood.

Abbreviations: H&E, haematoxylin and eosin; PET, pancreatic endocrine tumour.
noted. In view of the clinical impression of carcinoma of the pancreas a Whipple’s procedure was undertaken. Postoperatively, the patient developed abdominal sepsis that responded to antibiotics. The rest of her postoperative course was uneventful and she was discharged.

MATERIALS AND METHODS
The surgical pathology specimen consisted of the distal portion of the stomach, duodenum, and jejunum, the head of the pancreas, and the cystic duct. The specimen was dissected as per protocol and sections of routinely processed formalin fixed, paraffin wax embedded tissue were stained with H&E. A periodic acid Schiff preparation, with and without diastase digestion, and Southgate’s mucicarmine stain were also done. In addition, immunohistochemistry was performed for the following antibodies/antigens: chromogranin (Biomed, Foster City, California, USA), 1/400 dilution; synaptophysin (Dako, Ontario, Canada), 1/10 dilution; gastrin (Zymed, San Francisco, California, USA), 1/50 dilution; insulin (Dako), 1/4 dilution; glucagon (Novocastra, Newcastle upon Tyne, UK), 1/100 dilution; somatostatin (Zymed), 1/100 dilution; vasoactive intestinal peptide (Novocastra), 1/800 dilution; polypeptide P (Dako), 1/2000 dilution; CAM 5.2 (Becton Dickinson, San Jose, California, USA), 1/50 dilution; AE1/AE3 (Dako), 1/500 dilution; vimentin (American Research Products Inc, Belmont, Massachusetts, USA), 1/1200 dilution; Ki-67 (Immunotech, Westbrook, Maine, USA), 1/20 dilution.

Tissue was removed from a representative paraffin wax block and processed for electron microscopic examination.

GROSS PATHOLOGY
The stomach and duodenum were grossly unremarkable. The head of the pancreas measured 5.0 × 5.5 × 3.0 cm, and the superior aspect contained a well circumscribed tumour that measured 4.5 × 4.0 × 3.0 cm. On section, the tumour was firm, lobulated, glistening, and brown/tan to white in colour. The common bile duct measured 4.5 cm in length and 1.0 cm in circumference and was grossly unremarkable. The tumour did not compress or extend into the common bile duct. Fourteen lymph nodes were processed for histological evaluation.

MICROSCOPY
The tumour was arranged predominantly in a microglandular or tubulo/microacinar pattern, with focal trabecular and solid areas (fig 1). Within the microglandular structures the nuclei were basally oriented, with the apical portions of the cells containing abundant lightly eosinophilic, waxy hyaline material, organised into globules or inclusions within the cytoplasm. The hyaline inclusions occupied the luminal aspect of the microacinar structures and imparted an elongated appearance to the cells (fig 2). In some cells, the inclusions were sufficiently large to displace the nucleus eccentrically, resulting in a plasmacytoid or signet ring-like appearance (fig 3). In other cells, the inclusions assumed the more typical “rhabdoid” morphology, with deeply eosinophilic cytoplasmic inclusions and a peripherally displaced nucleus (fig 4). The inclusions were relatively uniform in size and distribution within the tumour cells. Cells arranged in trabeculae and solid sheets also contained inclusions. Extracellular hyaline was not seen. Those cells not containing inclusions had the typical finely granular, eosinophilic cytoplasm of classic endocrine cells. The nuclear chromatin had a “salt and pepper” distribution and several cells had small but distinct nucleoli. There was mild nuclear pleomorphism and the mitotic count ranged from four to nine/10 high power fields. Foci of necrosis with cholesterol clefts and...
foamy macrophages were present. The tumour infiltrated into fibrous tissue that was extremely hyalinised and calcified in areas, and into peripancreatic fibroadipose tissue. Both perineural and lymphatic permeation were noted. The hyaline inclusions were negative with the periodic acid Schiff, with and without diastase digestion, and mucin stains. All lymph nodes showed reactive change but no metastatic tumour. All resection margins were free of tumour.

The tumour cells were strongly positive for epithelial markers (CAM 5.2 and AE1/3); these keratin stains highlighted a conspicuous dot-like or globular staining pattern of the hyaline inclusions (fig 5). Vimentin also highlighted the cytoplasmic globules. In addition, synaptophysin was diffusely positive, whereas chromogranin A was only focally positive. The Ki-67 labelling index was approximately 6%. All other markers were negative. The tumour was diagnosed as a low grade, non-functional, malignant endocrine tumour, according to the World Health Organisation classification.

Electron microscopy revealed the presence of aggregates of juxtanuclear intermediate filaments with entrapped neurosecretory granules (fig 6).

DISCUSSION
A wide array of cytoskeletal abnormalities is encountered at different sites and under different pathological conditions. Benign and malignant conditions of the liver, ovarian tumours, renal cell carcinomas, renal oncocytomas, soft tissue sarcomas, and central nervous system tumours have all been noted to contain hyaline bodies of some type.

Thus far, only two reports of so called “rhabdoid” pancreatic endocrine tumours have appeared in the literature. In an analysis of pancreatic endocrine tumours in our records, cells of this morphology have been noted focally in occasional cases. However, the case presented in this report is the only one encountered thus far composed of a large population of “rhabdoid” cells.

The prototypic inclusion body in endocrine lesions is the fibrous body seen in some pituitary adenomas, especially the sparsely granulated somatotroph adenoma. The seminal observation of these juxtanuclear intermediate filaments was by Racadot and colleagues in 1964. The cells of the pituitary adenoma that they described were characterised by round hyaline masses often indenting or causing a concavity of the nucleus. Electron microscopic examination showed that these bodies consist of aggregates of intermediate filaments in which occasional neurosecretory granules and mitochondria were also present. Cardell and Knighton were the first to use the term “fibrous bodies”, which has become the most common and frequently used term to describe this phenomenon in the pituitary.

Conditions in which cytoplasmic juxtanuclear aggregates of intermediate filaments are present are diverse and the pathogenesis of these structures is not known. It has been suggested that they are caused by cell damage and apoptosis. However, not all cells with intracytoplasmic inclusions exhibit evidence of damage. Indeed, in pituitary tumours, there is no correlation between the formation of
fibrous bodies and evidence of cell damage. Among pituitary growth hormone producing adenomas, the densely granulated tumours lack fibrous bodies; these lesions tend to occur in younger patients, often express prolactin and the α subunit of glycoprotein hormones, harbour Gsα mutations, and respond well to somatostatin analogue treatment. In contrast, sparsely granulated somatotroph adenomas are diagnosed on the basis of the fibrous body formation; these lesions tend to occur in older patients, are rarely plurithormonal, do not harbour Gsα mutations, and do not respond well to somatostatin analogues.

The appearance of these filamentous structures in H&E stained sections is variable; some tumours may not have detectable inclusions within the cytoplasm. They may be seen on toluidine blue stained, plastic embedded, semi-thin sections as a well defined, pale, globoid cytoplasmic inclusion. In some cases, they represent an ultrastructural observation only. However, keratin immunohistochemistry highlights the presence of juxtanuclear globular structures. At the ultrastructural level, intracytoplasmic fibrillary inclusions or whorls have been noted in endocrine tumour of the bronchus and rectum, paragangliomas of the cauda equina, and in an endocrine tumour of the pancreas. Para-neuronal or juxtanuclear intermediate filaments are also characteristic of Merkel cell neuroendocrine carcinomas.

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The term “rhabdoid” has been used to describe tumours composed of cells with globular cytoplasmic inclusions that are intensely eosinophilic/acidophilic. It is obviously reflective of the striking similarity and resemblance to rhabdomyoblasts. Thus, a recently described case similar to the one we present was identified as a “rhabdoid” pancreatic neuroendocrine carcinoma. The nomenclature describes a “rhabdomyoblast-like” appearance but implies that the cells are not true rhabdomyoblasts. The term has been further exploited to describe “rhabdoid-like” inclusions—pale, lightly eosinophilic cytoplasmic inclusions within a deeply eosinophilic cytoplasm that are keratin negative and are composed of both thick and thin filaments, not intermediate filaments. In contrast, the “signet ring cell” pancreatic tumour described by Stokes and colleagues was composed of cells with inclusion bodies consisting of multilayered, concentric, osmiophilic lamellae or myelin figures, ascribed to an abnormal accumulation of degenerating organelles. These features are different from the hyaline or plasmacytoid cells seen in myoepitheliomas and pleomorphic adenomas of salivary glands, in which the cells have a diffusely hyaline, eosinophilic cytoplasm with an eccentrically located nucleus, but do not have hyaline globular, inclusion-like bodies. The cell morphology that is highlighted in this case is also different from the commonly encountered “plasmacytoid” cells seen with air dried Diff-Quik stained fine needle aspiration specimens of endocrine tumours. Once again, cytoplasmic inclusions are not present.

The widespread use of “rhabdoid” as a purely descriptive term is somewhat entrenched in the literature, with an ever expanding list of tumours (“composite extrarenal rhabdoid tumours”) exhibiting this characteristic cell type. The resemblance to rhabdomyoblasts is superficial and based on morphological mimicry, and “rhabdoid” does not reflect histogenesis or cell structure. In fact, it is merely a convenient term. In this context, it loses relevance and may lead to the erroneous interpretation of histogenesis in tumours harbouring cells with a similar morphology. We advocate the use of the descriptive term “cytokeratin aggresomes” for tumours containing juxtanuclear aggregates of keratin filaments, because this is more reflective of the structural abnormality causing the characteristic morphological appearance. This term was first used by Johnston and colleagues to describe the redistribution of the intermediate filament protein vimentin to form a cage surrounding a pericentriolar core of aggregated, ubiquitinated protein. We feel that this phenomenon is especially true in the case of tumours with a neuroendocrine histogenesis, and because the same process occurs in the pituitary, the use of “cytokeratin aggresomes” is more inclusive and unifying. The exact incidence and relevance of cells bearing this characteristic morphology in pancreatic endocrine tumours is not clear at this juncture.

The use of the term “rhabdoid” in pancreatic endocrine tumours especially is not a particularly apt appellation, and is not necessarily reflective of histogenesis. The light microscopy of routinely stained H&E sections of some PETs may be normal, but there may be immunohistochemical and/or ultrastructural evidence of intracytoplasmic whorls of intermediate filaments. In other cases, cytoplasmic inclusions may be detected in individual cells or they may be highly conspicuous on routine sections examined by light microscopy. It is important to point out that a range of morphological appearances can be encountered as a result of cytoplasmic aggregates of intermediate filaments; some cells resembling signet ring cells and others “rhabdoid” cells. The case described here illustrates that intracytoplasmic juxtanuclear intermediate filaments can cause a range of cytymorphological appearances and that the application of the term “rhabdoid” as an all embracing term is inappropriate. The use of the term “fibrous bodies” (as seen and used in the pituitary) may also be inappropriate. “Cytkeratinaggresomes” does have the advantage of alluding to the pathological feature, rather than implying histogenesis, and does unify the identical process that occurs across several tumours.

Take home messages

- We describe a pancreatic endocrine tumour with an unusual morphological appearance
- This case highlights the spectrum of changes that can be seen with cytoplasmic, juxtanuclear intermediate filament aggregation and that the application of the term “rhabdoid” as an all embracing term is inappropriate
- Use of the term “cytokeratin aggresomes” has the advantage of alluding to the pathological feature, rather than implying histogenesis, and unifies the identical process that occurs across several tumours

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