**CASE REPORT**

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.

Pancreatic endocrine tumours (PETs) are usually composed of uniform cells with eosinophilic, granular cytoplasm and nuclei containing chromatin with a “salt and pepper” distribution. However, endocrine cells encountered in these lesions may show variable morphological alterations, including oncocytic change, clear cytoplasm, rhabdoid features, small intracytoplasmic eosinophilic globules, mucin accumulation resulting in goblet cell formation, and spindle cell morphology. An extremely rare variant is the so-called “signet ring” cell variant, which was described by Stokes et al in a non-functioning PET. The collection of variants of this lesion expands with each case report, but the importance of each remains unknown.

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We describe a pancreatic endocrine tumour composed of cells containing distinct intracytoplasmic hyaline appearing inclusion bodies. There was a superficial resemblance to signet ring cells because several of the inclusions were pale and clear. However, we feel that this term is misleading and is a misnomer, because the use of the term “signet ring” cell implies the presence of intracytoplasmic mucin vacuoles. The tumour cells had a homogeneous pale space within the cytoplasm on haematoxylin and eosin (H&E) staining, similar to those identified in so called “rhabdoid” tumours. This term also is not ideal, and is confusing because the term “rhabdoid”, meaning rhabdomyoblast like, implies a resemblance to rhabdomyoblasts that is characteristic of aggressive, dedifferentiated malignancies.

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 juxtaparuclear 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 juxtaparuclear cytokeratin immuno-reactive 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, juxtaparuclear 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 cytokeratin, juxtaparuclear 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.

**CASE REPORT**

A 50 year old woman presented to the emergency department with acute onset of abdominal pain, nausea, and vomiting. Although the clinical impression was of viral gastroenteritis, the patient was admitted, given fluids, and 48 hours later her symptoms resolved. An ultrasound and computed tomography examination of the abdomen was ordered. Both confirmed a well circumscribed, lobulated, 4.4 x 4.0 x 3.6 cm mass in the region of the head of the pancreas, which appeared to be hypervascular with areas of microcalcification. No spread to the liver or lymph nodes was detected.

**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 (Biomeda, 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 other 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

Figure 1 The tumour had a dominant tubulopapillary appearance with only focal solid and trabecular foci. Haematoxylin and eosin stain; original magnification, ×100.

Figure 2 The inclusions were present in the luminal aspect of the cytoplasm, causing the cells to appear elongated and tall. Haematoxylin and eosin stain; original magnification, ×400.

Figure 3 Some of the intracytoplasmic inclusions were very pale and weakly eosinophilic. In these cells the inclusions imparted a signet ring appearance to the cells. Haematoxylin and eosin stain; original magnification, ×400.
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 oncocytes, 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...
fibrillary inclusions are not present. Although mitotically active cells may contain eosinophilic cytoplasmic inclusions resembling those in myoepithelial cells, the presence of these cytoplasmic inclusions is not an absolute criterion for adenoid cystic carcinoma. The presence of cytoplasmic inclusions does not imply that the tumour arises from ductal epithelium. In contrast, sparsely granulated somatotroph adenomas are composed of cells with inclusion bodies consisting of multilayered, eosinophilic cytoplasmic inclusions. 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 tumours of the bronchus and rectum, paragangliomas of the cauda equina, and in an endocrine tumour of the pancreas.21 Paranuclear or juxtanuclear intermediate filaments are also characteristic of Merkel cell neuroendocrine carcinomas.

The term “rhabdoid” has been used to describe tumours composed of cells with globular cytoplasmic inclusions that are intensely eosinophilic/acidophilic.22 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.3 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.23 In contrast, the “signet ring cell” pancreatic tumour described by Stokes and colleagues21 was composed of both thick and thin filaments, not intermediate filaments.23 In contrast, the term “rhabdoid” has been used to describe tumours containing juxtanuclear aggregates of keratin filaments, because this is more reflective of the structural abnormality causing the characteristic morphological appearance.24 This term was first used by Johnstone and colleagues to describe the redistribution of the intermediate filament protein vimentin to form a cage surrounding a pericentriolar core of aggregated, ubiquitinated protein.25 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 cytomorphological 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. “Cytokeratin aggresomes” 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.

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