Granulosa cells are cells of sex cord derivation, which line developing follicles and follicular cysts within the ovary. Morphologically, granulosa cells are characterised by central bland or mildly atypical hyperchromatic nuclei. In the developing follicle, mitotic activity may be conspicuous. In this report, we describe a series of cases in which benign granulosa cells were present within ovarian vascular channels and typically led the original pathologist to consider a tumour as the explanation. Although vascular invasion by benign granulosa cells is described in some books, we are aware of only a single case report of this phenomenon that has been published in a clinical journal.

\section*{MATERIALS AND METHODS}

Four of the cases were identified from the consultation files of Dr R E Scully and two were seen in consultation by the authors. Specimens had been fixed in formalin and routinely processed in paraffin wax. In four cases, selected immunohistochemistry as detailed below was performed according to standard protocols. The number of slides showing the phenomenon of artefactual vascular invasion ranged from one to four. It was not possible to ascertain whether the involved vessels were lymphatic vessels or blood vessels, and we use the term “vascular” as a generic term to describe both.

\section*{RESULTS}

Table 1 shows patient details, accompanying pathological findings, and the referral diagnoses. All patients were premenopausal. In case 6, there was a history of resection of a cervical squamous carcinoma three years earlier.

In all cases, several small ovarian vascular channels contained cohesive groups of mildly atypical cells with an epithelioid appearance (fig 1). The number of vascular channels containing granulosa cells ranged from one to eight. Nuclei were round to ovoid, hyperchromatic, and nuclear grooves were not identified. In three cases, the cells had an appreciable amount of eosinophilic cytoplasm (fig 2), whereas in the three other cases the amount of cytoplasm was scant (fig 3). In these last three cases, the nuclei sometimes appeared crushed, resembling small cell carcinoma (fig 3). In four cases, mitotic figures were identified (fig 4). In three cases, occasional cohesive groups of cells appeared to lie within the ovarian stroma (fig 5). In four cases, there was a nearby follicle lined by granulosa cells (fig 6). In these cases, the follicle became more conspicuous on levelling the block.

Using immunohistochemistry, the cells within the vascular channels in case 1 were positive for \(\alpha\) inhibin (fig 7) and calretinin (fig 8), but negative for epithelial membrane antigen (EMA) and cytokeratin. In case 2, the cells were positive for cytokeratin (punctate cytoplasmatic staining) and negative for chromogranin, leucocyte common antigen (LCA), and carcinoembryonic antigen. In case 3, the cells were positive for vimentin and negative for carcinoembryonic antigen and cytokeratin. The cells in case 4 were positive for vimentin and cytokeratin and negative for LCA. Immunohistochemistry was not performed in cases 5 and 6 because a confident diagnosis was rendered on routine stains.

\section*{DISCUSSION}

One of the main areas that makes diagnostic surgical pathology an art as much as a science is the interpretation of cases in which changes seen under the microscope are artefactual. In some cases, such artefacts may cause a benign lesion to be misdiagnosed as malignant. The presence of mildly atypical granulosa cells within ovarian vascular channels and stroma in the cases we have described resulted in consideration of a malignant lesion. In four cases, the artefacts were not needed.
presence of a nearby follicle lined by granulosa cells, often seen more clearly on levelling the block, was a clue to the nature of the cells. Because mitotic activity can be conspicuous in developing follicles, it is not surprising that in four of our cases mitoses were identified within the cells involving vascular channels.

In three cases, the preferred referral diagnosis was metastatic carcinoma, and in some cases further investigations were undertaken to exclude a carcinoma. However, it would be extremely unusual for a metastatic lesion to present in the ovary with only vascular involvement. When a metastasis to the ovary presents in an occult manner, there is usually a mass lesion grossly, or at least a mass lesion of microscopic dimension effacing a small part of the parenchyma, as opposed to entirely vascular invasion. In two cases, the presence of cells with abundant eosinophilic cytoplasm, presumably representing cytoplasmic luteinisation, was reminiscent of metastatic breast carcinoma, whereas in another case a diagnosis of metastatic squamous carcinoma was considered because of the history of resection of a cervical squamous carcinoma three years earlier. The crushed nuclei and scant cytoplasm in some cases were reminiscent of a small cell carcinoma or a lymphoma, and other diagnoses entertained included metastatic malignant melanoma and carcinoid tumour.

Negative staining with neuroendocrine markers would help to exclude a small cell carcinoma, although some small cell carcinomas are negative. The cohesive nature of the cells argue against a lymphoma, and negative staining for LCA helps to exclude this diagnosis, because most morphological subtypes of lymphoma are positive. In excluding malignant melanoma and carcinoid tumour, melanocytic and neuroendocrine markers, respectively, would be of value. Benign mesothelial cells were also suggested in the differential diagnosis by the referring pathologist in one case. In excluding mesothelial cells, immunohistochemistry with antibodies directed against mesothelial markers may be of value, although it should be noted that calretinin is commonly positive in both mesothelial and sex cord stromal cells. In this regard, other mesothelial markers such as HBME1, thrombomodulin, and cytokeratin 5/6 may be of value.

In two cases, the ovary containing granulosa cells within vascular channels also harboured a benign cystic teratoma. This resulted in consideration of immature neural elements and an immature teratoma. However, the presence of immature neural elements within vascular channels would be unusual, and there was no background fibrillary material or rosette formation, features that are often seen in immature neural elements.

"Once it is realised that the cells within vascular channels are probably granulosa cells confirmation is easy using immunohistochemistry."

Another entity to be considered in the differential diagnosis is a granulosa cell tumour with vascular invasion. In this instance, immunohistochemistry would be of no value, but a granulosa cell tumour is easily excluded by the absence of a mass lesion grossly or histologically. In addition, the nuclei of granulosa cell tumours are usually pale and have easily identifiable nuclear grooves, in contrast to the hyperchromatic non-grooved nuclei of benign granulosa

Table 1  Patient details, pathological findings, and referral diagnoses

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Operation</th>
<th>Other pathology in ovary with granulosa cells in lymphovascular channels</th>
<th>Other pathology</th>
<th>Referral diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>47</td>
<td>TAH+BSO</td>
<td>None</td>
<td>Uterine leiomyomas</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Case 2</td>
<td>46</td>
<td>TAH+BSO</td>
<td>Endometriosis</td>
<td>Endometriosis other ovary; adenomyosis</td>
<td>Malignant adenocarcinoma, probably from breast; ?carcinoid</td>
</tr>
<tr>
<td>Case 3</td>
<td>44</td>
<td>TAH+BSO</td>
<td>Endometriosis</td>
<td>Endometriosis other ovary</td>
<td>Adenocarcinoma breast; ?carcinoid; metastatic malignant melanoma;</td>
</tr>
<tr>
<td>Case 4</td>
<td>37</td>
<td>LSO</td>
<td>Benign cystic teratoma (struma ovarii)</td>
<td>None</td>
<td>Metastatic adenocarcinoma, probably from breast; ?carcinoid; metastatic malignant melanoma;</td>
</tr>
<tr>
<td>Case 5</td>
<td>22</td>
<td>RSO</td>
<td>Benign cystic teratoma</td>
<td>None</td>
<td>Metastatic adenocarcinoma, probably from breast; ?carcinoid; metastatic malignant melanoma;</td>
</tr>
<tr>
<td>Case 6</td>
<td>31</td>
<td>BSO</td>
<td>Follicular cysts</td>
<td>Follicular cysts other ovary; squamous cell carcinoma cervix 3 years earlier</td>
<td>Metastatic squamous carcinoma</td>
</tr>
</tbody>
</table>

BSO, bilateral salpingo-oophorectomy; LSO, left salpingo-oophorectomy; RSO, right salpingo-oophorectomy; TAH+BSO, total abdominal hysterectomy and bilateral salpingo-oophorectomy.
cells. Furthermore, prominent vascular invasion is unusual in granulosa cell tumours.

Once it is realised that the cells within vascular channels are probably granulosa cells confirmation is easy using immunohistochemistry. Benign granulosa cells, like granulosa cell tumours, are generally positive for α inhibin and calretinin and negative for EMA. Some granulosa cell tumours are positive for cytokeratin, often showing a punctate cytoplasmic staining pattern, and in two of our cases the granulosa cells within the vascular channels were cytokeratin positive. Of course, positivity for cytokeratin may heighten the suspicion of metastatic carcinoma. In the single previous report of benign granulosa cells within ovarian vascular channels, positivity with antibodies reactive against sex cord stromal cells, including α inhibin, assisted in confirming the nature of the cells.
We believe the occurrence of granulosa cells within vascular channels, and within the ovarian stroma, to be either an artefact related to surgical trauma or cutting of the specimen in the laboratory, or alternatively secondary to ovulation. Granulosa cells, although joined by rudimentary junctions, do not contain well formed desmosomes, and this may render them especially susceptible to traumatic detachment and incorporation within vascular channels. The crushed nature of the cells in some cases also suggests a traumatic effect.

In summary, we describe a series of cases characterised by involvement of ovarian vascular channels by benign granulosa cells. Pathologists should be aware of this rare phenomenon to avoid erroneous diagnoses with subsequent unnecessary investigations. Awareness of the phenomenon and lack of other evidence of neoplasia will prompt the correct interpretation, and the nature of the cells can be confirmed by immunohistochemistry using a panel of antibodies, including those directed against α inhibin, calretinin, and epithelial membrane antigen.

## ACKNOWLEDGEMENTS

We would like to record that Dr R E Scully first drew the attention of one of us (RHY) to this artefactual phenomenon some years ago. We are grateful to Dr Scully for generously allowing us to report the four cases in this report from his files.

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## REFERENCES


