CASE REPORT

Primitive neuroectodermal tumour of the cervix: a rare diagnosis

Irfan Ahmad,[1] Kundan Singh Chufal,[1] Amit Bhargava,[2] Irfan Bashir[1]

[1]Department of Radiation Oncology, Batra Hospital & Medical Research Centre, New Delhi, Delhi, India
[2]Department of Medical Oncology, Batra Hospital & Medical Research Centre, New Delhi, Delhi, India

Correspondence to
Dr Irfan Ahmad,
irfan.a@icloud.com

Accepted 18 December 2016

SUMMARY

A 48-year-old woman presented with symptoms of lower abdominal pain and vaginal discharge for 6 months. Clinical examination and pelvic ultrasound scan suggested a diagnosis of infected Gartner's cyst, for which she underwent vaginal cystectomy. However, histopathology and immunohistochemistry revealed a diagnosis of primitive neuroectodermal tumour of the cervix. Further investigations revealed the stage to be FIGO IIIB, which was inoperable. She received neoadjuvant chemotherapy (vincristine, adriamycin, cyclophosphamide alternating with ifosfamide, cisplatin and etoposide, every 21 days), but the tumour did not respond to treatment and she was started on radiotherapy with definitive intent (55.8 Gray in 31 fractions over 6.2 weeks). A PET-CT performed 2 months after completion of radiotherapy showed complete response, and she is now receiving adjuvant chemotherapy.

BACKGROUND

Primitive neuroectodermal tumour (PNET) and Ewing's sarcoma are a spectrum of tumours, with typical undifferentiated Ewing's sarcoma at one end and PNET at the other with clear neuronal differentiation. Both harbour a gene rearrangement involving the EWS gene on chromosome 22.[1 2] The translocation t(11;22)(q24;12), also known as EWS-FLI1, is the most commonly reported (85–90% of cases) but others may also occur (t(21;22)(q22;12), t(17;22), t(7;22), t(22;22) and inv(22)).[3–7] The translocation involving EWS gene defines the inclusion of these tumours into the Ewing's family of tumours (EFT), which arise from mesenchymal progenitor cells and occur most commonly at osseous sites.[8 9] They are categorised based on distribution as central PNET (involving brain and spinal cord) or peripheral PNET (involving sympathetic nervous system, skeleton and soft tissue). EFTs as a group are rare tumours with a reported incidence of 1 per million, and extraosseous presentations are even rarer.[10]

PNET of the cervix is an exceedingly rare entity, and to the best of our knowledge only 20 cases have been reported in the English language literature. The management of this rare tumour has varied over time, and the most accepted protocol is that of induction chemotherapy followed by locally directed treatment (surgery and/or radiotherapy) and adjuvant chemotherapy, which mirrors the management for osseous PNET.[11] Here, we describe the 21st case of PNET of cervix along with a review of all the cases reported so far.

CASE PRESENTATION

A 48-year-old hypertensive, postmenopausal woman initially presented to her gynaecologist with symptoms of dull, aching pain in the lower abdomen which was associated with whitish vaginal discharge for the last 6 months. General physical examination was unremarkable. Eastern Cooperative Oncology Group (ECOG) performance status was 0. Abdominal examination did not reveal any localised tenderness or mass. On speculum examination, a cystic lesion was seen arising from the cervix circumferentially and involving the anterior wall of vagina. There was no involvement of the parametrium or recto-vaginal septum on bimanual examination.

INVESTIGATIONS

On pelvic ultrasound scan, a heterogeneous lesion was visualised which measured 6×5×4 cm along the anterolateral aspect of the vaginal wall up to the middle one-third. The initial diagnosis was that of an infected Gartner's cyst, and she underwent a vaginal cystectomy. Per-op findings revealed a friable, cystic lesion with interspersed solid and haemorrhagic areas.

Histopathological evaluation revealed a poorly differentiated malignant tumour, with the pathological differential diagnosis of either carcinoma or melanoma. Immunohistochemistry (IHC) evaluation revealed CD99 (MIC2) strong positive, synaptophysin weak positive and CytoKeratin (CK), Human Melanoma Black-45 (HMB 45), Melan-A, Chromogranin-A (CgA) negative. Owing to cost constraints, the reciprocal translocation t(11;22)(q24;12) could not be tested. Other laboratory examinations for haematology, liver and renal function tests were normal.

A diagnosis of PNET of the cervix (International Federation of Gynaecology and Obstetrics (FIGO) stage IIA2) was made, at which point she was referred to our institution, where she underwent an MRI of the pelvis and a whole body ^{18}Flouro-Deoxy-Glucose Positron Emission Tomography-CT (^{18}FDG PET-CT) scan. MRI revealed an ill-defined circumferential mass lesion involving the cervix and vagina with intralesional cystic/necrotic foci (figure 1) and restricted diffusion on diffusion weighted imaging (DWI). The lesion was indenting the posterior wall of the urinary bladder anteriorly and the rectum posteriorly without any evidence of definite invasion. There was extension up to the left obturator internus muscle. A whole body ^{18}FDG PET-CT scan revealed a large heterogeneously enhancing soft tissue mass with increased

To cite: Ahmad I, Chufal KS, Bhargava A, *et al*. *BMJ Case Rep* Published online: [*please include* Day Month Year] doi:10.1136/bcr-2016-217461

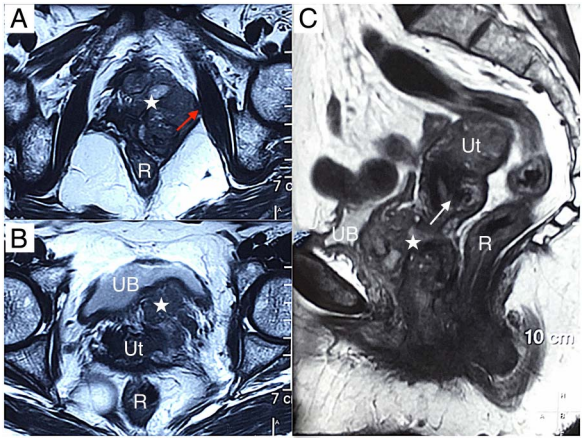

Figure 1 Contrast-enhanced MRI of the pelvis. (A) Axial section showing the mass lesion (star) indenting the left obturator internus muscle (red arrow). (B) Axial section showing the mass in relation to the urinary bladder anteriorly and rectum posteriorly. Note that despite indenting the urinary bladder, there is no evidence of definite invasion. (C). Coronal section showing the mass arising from the cervix (white arrow) and extending into the vagina. R, rectum; UB, urinary bladder; Ut, uterus.

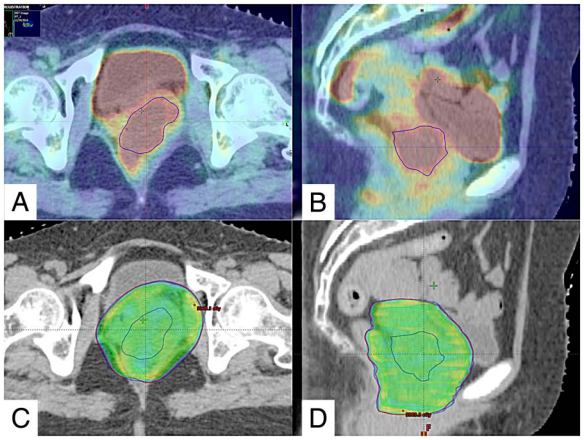

Figure 2 Postchemotherapy PET-CT registered with contrast-enhanced CT simulation scan. (A and B) Axial and coronal images show the GTV (contoured in blue) based on PET images. (C and D) Axial and coronal images showing the coverage of the PTV (red contour) with dose colour wash from VMAT planning. Dose is shown with the lower limit set to 95% of 50.4 Gy.

FDG uptake involving the cervix and vaginal canal measuring 6×5.5 cm (standardised uptake value$_{max}$ 7.58), without any evidence of distant metastases. The final stage of the patient was FIGO IIIB.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of a primary sarcoma of the cervix (a rare entity in itself) includes leiomyosarcoma, rhabdomyosarcoma, alveolar soft-part sarcoma, liposarcoma, undifferentiated endocervical sarcoma and osteosarcoma.[12]

TREATMENT

The case was discussed in our tumour board, and she was planned for neoadjuvant chemotherapy with vincristine, adriamycin, cyclophosphamide (VAC) for three cycles alternating with ifosfamide, cisplatin, etoposide (ICE) for three cycles, both to be delivered every 21 days followed by a response assessment via whole body ^{18}FDG PET-CT. The chemotherapy dose administered was as follows: vincristine 2 mg intravenous on day 1, adriamycin 75 mg/m^2 intravenous on day 1, cyclophosphamide 1200 mg/m^2 intravenous on day 1, ifosfamide 1800 mg/m^2 intravenous on days 1–5 (along with Mesna), cisplatin 40 mg/m^2 intravenous on days 1–3, etoposide 100 mg/m^2 intravenous on days 1–5. Prior to treatment delivery, the cumulative dose of adriamycin to be delivered was capped at 375 mg/m^2 after which it was to be replaced with actinomycin D 1.25 mg/m^2 intravenous on day 2. A baseline echocardiogram was also performed prior to chemotherapy, which was normal.

However, after successfully receiving neoadjuvant chemotherapy, the tumour did not show any significant reduction in size or FDG avidity. Owing to extension of the tumour up to the left lateral pelvic wall, the patient was planned for radical radiotherapy, up to a total dose of 55.8 Gy in 31 fractions with a fraction size of 1.8 Gy, delivered via image-guided volumetric modulated arc therapy (VMAT) with 6 megavoltage (MV) photons.

In brief, postchemotherapy PET-CT images were fused with the simulation CT scan, and all FDG-avid disease was contoured as gross tumour volume (GTV). This volume was expanded isotropically by 1.5 cm (following guidelines for Ewing's sarcoma at other bony sites) and modified to include the uterus and vagina, to create the clinical target volume (CTV).[10] A final planning target volume (PTV) expansion of 5 mm was given as per institutional protocol (figure 2), and daily imaging verification prior to delivery (via either kV orthogonal planar imaging or cone beam CT) was performed. Elective pelvic nodal irradiation was not performed.[10] After the first phase of treatment until 50.4 Gy, replanning was carried out to incorporate a 5.4 Gy boost, which was carried out by expanding the initial GTV by 5 mm isotropically to generate the boost PTV. Planning was carried out on Eclipse V.13.5 (Varian Medical Systems, Palo Alto, California, USA) and treatment was delivered on Varian Clinac 2100c (Varian Medical Systems, Palo Alto, California, USA).

OUTCOME AND FOLLOW-UP

The patient received radiotherapy without experiencing any significant toxicity and serial CBCTs during treatment showed significant reduction in size. A PET-CT was performed 2 months after completion of radiotherapy, and it showed complete response to treatment when compared to the pretreatment PET-CT. She is now receiving adjuvant chemotherapy with VAC alternating with ICE.

DISCUSSION

Sporadic cases of PNET been reported in the uterus, vagina and vulva, with the ovary being the most common site in the female genital tract.[13] First reported by Russin *et al*,[14] PNET of the cervix is a rare tumour with the literature search revealing only 20 patients reported so far in the English language literature. Diagnosis of these tumours is challenging for clinicians and pathologists, with all cases reported relying on IHC to establish the diagnosis. The most characteristic marker on IHC is diffuse CD99 (MIC2) positivity, which is present in nearly all EFT.[15 16]

We have summarised the previously reported cases in table 1. The most common presenting symptom was irregular vaginal bleeding, with the age at presentation varying from 19 to 60 years. Two cases were diagnosed in pregnant women.[17 18] The most common physical examination findings were that of

Table 1 Clinicopathological characteristics of patients with PNET of cervix

	Author, year of publication	Age (years), presenting symptom	Diagnosis/FIGO stage	IHC markers	Treatment	Follow-up
1	Russin *et al*, 1987[14]	60, Vaginal bleeding	Pathology, IHC/IB	NSE	TAH, BSO, LND followed by adjuvant radiotherapy and chemotherapy (VAC for 6 weeks)	NED at 16 months
2	Sato *et al*, 1996[23]	44, Vaginal bleeding	Pathology, IHC/IB_2	68 kDa, NSE, tyrosine hydroxylase	TAH, left oophorectomy, LND followed by adjuvant chemotherapy (adriamycin, cyclophosphamide, cisplatin and etoposide) for six cycles and then second look surgery	NED at 6 months
3	Horn *et al*, 1997[24]	26, Suspicious cervical smear	Pathology, IHC/IB_1	NSE	TAH, BSO, LND followed by adjuvant radiotherapy	Died of metastatic disease at 50 months
4	Cenacchi *et al*, 1998[20]	36, Vaginal bleeding	Pathology, IHC, RT-PCR/IB_2	CD99, p30, p32	TAH without BSO	NED at 18 months
5	Pauwels *et al*, 2000[19]	45, Vaginal bleeding	Pathology, IHC, FISH/IB_2	Vimentin, S-100, Leu7, NSE	TAH without BSO followed by adjuvant radiotherapy	NED at 42 months
6	Tsao *et al*, 2001[25]	24, Vaginal bleeding and urinary frequency	Pathology, IHC/IB_2	CD99, vimentin	Neoadjuvant chemotherapy (two cycles of VAC alternating with IE) followed by TAH, transposition of ovaries, LNS and adjuvant chemotherapy (two cycles of VAC alternating with IE) followed by radiotherapy	NED at 24 months
7	Malpica *et al*, 2002[26]	35, Vaginal bleeding	Pathology, IHC/IB_1	CD99	TAH, BSO with selective para-aortic and pelvic LND followed by adjuvant chemotherapy (regimen not reported)	NED at 5 months
8	Malpica *et al*, 2002[26]	51, Vaginal bleeding	Pathology, IHC/IB_2	CD99	TAH, BSO with selective para-aortic and pelvic LND followed by adjuvant chemotherapy (regimen not reported)	NED at 18 months
9	Snijders-Keilholz *et al*, 2005[27]	21, Intermenstrual bleeding	Pathology, IHC/IB_2	CD99	Neoadjuvant chemotherapy (six cycles of DIME) followed by TAH (without adnexectomy or LND) and adjuvant chemotherapy (five cycles of VIA)	NED at 27 months
10	Goda *et al*, 2006[28]	19, Vaginal bleeding and discharge	Pathology, IHC/IIIB	CD99	Neoadjuvant chemotherapy (VAC) followed by RT and planned adjuvant chemotherapy	On treatment when reported
11	Farzaneh *et al*, 2011[29]	43, Vaginal discharge	Pathology, IHC/IB_2	CD99, Chromogranin A, Synaptophysin	Neoadjuvant chemotherapy (VAC alternating with IE for 12 weeks) followed by TAH, BSO, LNS and adjuvant chemotherapy (VAC alternating with IE for 12 weeks)	NED at 48 months
12	Benbrahim *et al*, 2015[30]	25, Vaginal bleeding	Pathology, IHC/IIB	CD99, Vimentin, Synaptophysin, NSE, Ki-67	Neoadjuvant chemotherapy (one cycle of CHOP followed by four cycles of AC) followed by conization and adjuvant brachytherapy (received only 45 Gy of planned 60 Gy)	NED at 8 years
13	Arora *et al*, 2012[31]	23, Vaginal bleeding and dysuria	Pathology, IHC/ stage not reported	CD99	Neoadjuvant chemotherapy (one cycle of VAC followed by cisplatin+etoposide for two cycles) followed by TAH, BSO, LND and adjuvant radiotherapy	NED at 48 months
14	Masoura *et al*, 2012[21]	23, Vaginal bleeding and abdominal pain	Pathology, IHC, RT-PCR/IVB	CD99, vimentin, c-kit	TAH, BSO followed by one cycle of adjuvant cisplatin	Died of disease, 12 days postsurgery
15	Li *et al*, 2013[32]	27, Vaginal bleeding and abdominal pain	Pathology, IHC/IIIB	CD99, CD56, CD117, NSE, vimentin	Radiotherapy followed by adjuvant chemotherapy (VAC alternating with IE)	NED at 6 months
16	Khosla *et al*, 2014[17]	28, Vaginal bleeding and pelvic pain during 10th week of pregnancy	Pathology, IHC/IB_2	CD99, vimentin, NSE	Termination of pregnancy followed by TAH, BSO, LNS and adjuvant chemotherapy (adriamycin, ifosfamide and etoposide for three cycles) interspersed with radiotherapy followed by same chemotherapy for another six cycles.	NED at 33 months
17	Xiao *et al*, 2014[33]	52, Vaginal bleeding	Pathology, IHC/IIA	CD99, vimentin	TAH, BSO, LND and cytoreductive surgery followed by two cycles of adjuvant chemotherapy with cisplatin, vincristine and bleomycin	Died of disease at 9 months
18	Xiao *et al*, 2014[33]	59, Vaginal bleeding and cervical prolapse	Pathology, IHC/IVB	CD99, synaptophysin, NSE, neurofilament	TAH, BSO, LND, partial small intestinal excision	Died of disease, 15 days postsurgery
19	Al-Nueimy and Mahmood, 2014[18]	27, Obstructed labour	Pathology, IHC/IB_2	CD99, NSE	caesarean section followed by TAH, BSO, LNS	NED, Follow-up duration not reported
20	Mashriqi *et al*, 2015[22]	49, Vaginal bleeding and abdominal pain	Pathology, IHC/IIB	CD99	Radiotherapy with concurrent cisplatin and etoposide for two cycles followed by TAH, BSO and then adjuvant chemotherapy (VAC alternating with IE)	Died of disease at 10 months
21	Present case	50, Vaginal discharge and abdominal pain	Pathology, IHC/IIIB	CD99, Synpatophysin	Neoadjuvant chemotherapy with VAC alternating with ICE followed by radiotherapy and planned adjuvant chemotherapy with the same	On treatment

AC, adriamycin and cyclophosphamide; BSO, bilateral salpingo-oopherectomy; CHOP, cyclophosphamide, adrimaycin, vincristine, prednisone; DIME, doxorubicin, ifosfamide, mesna, etoposide; ICE, ifosfamide, cisplatin, etoposide; IE, ifosfamide, etoposide; LND, lymph node dissection; LNS, lymph node sampling; NED, no evidence of disease; TAH, total abdominal hysterectomy; VAC, vincristine, adriamycin, cyclophosphamide; VIA, vincristine, ifosfamide, dactinomycin.

mass lesions extending into the vagina and an enlarged uterus. The majority of cases were diagnosed on the basis of histopathology and IHC, with cytogenetic analysis carried out in only one case.[19] Reverse Transcriptase PCR (RT-PCR) was performed in two cases[20 21] and fluorescence in situ hybridization (FISH) was performed in two cases.[19 22] Seventeen cases, including ours were positive for CD99, and the rest were positive for NSE on IHC.

Owing to the rarity of this tumour, management was varied. Twelve patients were treated with upfront surgery, six patients with upfront chemotherapy and two with upfront radiotherapy. Among patients treated with surgery, five underwent lymph node dissection (LND), two underwent lymph node sampling (LNS), two underwent selective LND and three underwent no LND. As pointed out by Mashriqi *et al*,[22] the contribution of LND to overall survival is unclear. Nine of 12 cases treated with upfront surgery also received adjuvant treatment (either chemotherapy, radiotherapy or both). Of these, three patients died compared to one among those who did not receive adjuvant treatment. Interestingly, all patients who received neoadjuvant chemotherapy (followed by either surgery or radiotherapy) were disease free and alive at previous follow-up. This suggests that neoadjuvant chemotherapy followed by local treatment (and adjuvant chemotherapy) may be the most effective protocol in the management of this rare tumour.

The regimens of chemotherapy used in patients have also varied. Overall 16 patients received chemotherapy as part of multimodality treatment and 6 patients received neoadjuvant chemotherapy. In more recent cases, the use of VAC alternating with ifosfamide, etoposide (IE) has increased with favourable results, reflecting current recommendations for osseous PNET.[11]

Overall nine patients received radiotherapy with the majority in the adjuvant setting, and only two patients received upfront radiotherapy (one with concurrent chemotherapy). To the best of our knowledge, none of the patients received radiotherapy via VMAT or incorporated PET registration, which is the technique we employed in our patient to maximise sparing of the adjacent organs-at-risk (bladder, rectum, sigmoid colon, vulva) and to permit safe dose-escalation to 55.8 Gy.

Excluding the patients with FIGO stage IVB, both of whom died within 2 weeks post-surgery, follow-up has ranged from 5 months to 8 years without any evidence of disease. Xiao *et al*[33] have suggested that CA-125 levels may be elevated in patients with PNET of the female genital tract and may correlate with disease activity.

In conclusion, PNET of the cervix is a rare tumour, the diagnosis of which can be arrived at by IHC and cytogenetics. It should be managed with the multimodality approach incorporating all available information.

Learning points

- Considering the rarity of primitive neuroectodermal tumour (PNET) of cervix, excluding other differentials first is important and genetic study for EWS-FLI1 should ideally be performed.
- Standard protocol for treatment should be followed as per osseous PNET, which is neoadjuvant chemotherapy followed by local treatment and then adjuvant chemotherapy.
- Considering good overall prognosis (following standard treatment protocol), attention should be given to radiotherapy technique, in order to prevent late morbidity.

Twitter Follow Irfan Ahmad @irfanROres

Acknowledgements The authors thank Mr C.P. Bhatt (Consultant Radiation Physicist & Chief Radiation Safety Officer, Department of Radiation Oncology, BHMRC) for his valuable input. They also acknowledge Mr Lalit Sharma (Chief Technologist, Department of Radiation Oncology, BHMRC) and Mr Sandeep Rathour (Senior Technologist, Department of Radiation Oncology, BHMRC) for their valuable contribution.

Contributors IA is the treating senior resident (Radiotherapy), author of the paper, responsible for drafting the manuscript and revising it. He is the guarantor. KSC is the supervising treating consultant (Radiotherapy) and participated in article formulation, editing and oversight. AB is the supervising treating consultant (Medical Oncology) and participated in article editing and oversight. IB is the treating junior consultant (Radiotherapy) and participated in article formulation and editing.

Competing interests None declared.

Patient consent Obtained.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1 Aurias A, Rimbaut C, Buffe D, *et al*. Translocation involving chromosome 22 in Ewing's sarcoma. A cytogenetic study of four fresh tumors. *Cancer Genet Cytogenet* 1984;12:21–5.
2 Turc-Carel C, Phillip I, Berger MP, *et al*. Chromosome study of Ewing' sarcoma (ES) cell lines. Consistency of a reciprocal translocation t(11;22)(q24;q12). *Cancer Genet Cytogenet* 1984;12:1–19.
3 Zoubek A, Pfleiderer C, Salzer-Kuntschik M, *et al*. Variability of EWS chimaeric transcripts in Ewing tumours: a comparison of clinical and molecular data. *Br J Cancer* 1994;70:908–13.
4 Delattre O, Zucman J, Plougastel B, *et al*. Gene fusion with an ETS DNA-binding domain caused by chromosome translocation in human tumours. *Nature* 1992;359:162–5.
5 Zucman J, Delattre O, Desmaze C, *et al*. Cloning and characterization of the Ewing's sarcoma and peripheral neuroepithelioma t(11;12) translocation breakpoints. *Genes Chromosomes Cancer* 1992;5:271–7.
6 Sorensen PH, Lessnick SL, Lopez-Terrada D, *et al*. A second Ewing's sarcoma translocation t(21;22), fuses the EWS gene to another ETS-family transcription factor, ERG. *Nat Genet* 1994;6:146–51.
7 Machado I, Noguera R, Pellin A, *et al*. Molecular diagnosis of Ewing sarcoma family of tumors: a comparative analysis of 560 cases with FISH and RT-PCR. *Diagn Mol Pathol* 2009;18:189–99.
8 Jedlicka P. Ewing Sarcoma, an enigmatic malignancy of likely progenitor cell origin, driven by transcription factor oncogenic fusions. *Int J Clin Exp Pathol* 2010;3:338–47.
9 Kauer M, Ban J, Kofler R, *et al*. A molecular function map of Ewing's sarcoma. *PLoS One* 2009;4:e5415.
10 Indelicato D, Marcus RB. Ewing sarcoma. In: Lu JJ, Brady LW, eds. *Decision making in radiation oncology*. Berlin/Heidelberg: Springer Science & Business Media, 2011:1073–88.
11 ESMO/European Sarcoma Network Working Group. Bone sarcomas: ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. *Ann Oncol* 2014;25 (Suppl 3):iii113–23.
12 Kurman RJ, Zaino RJ, Norris HJ. Endometrial carcinoma. In: Kurman RJ, ed. *Blaustein's pathology of the female genital tract*. New York: Springer, 1994:439–86.
13 Kleinman GM, Young RH, Scully RE. Primary neuroectodermal tumors of the ovary: a report of 25 cases. *Am J Surg Pathol* 1993;17:764–78.
14 Russin VL, Valente PT, Hanjani P. Psammoma bodies in neuroendocrine carcinoma of the uterine cervix. *Acta Cytol* 1987;31:791–5.
15 Khoury JD. Ewing sarcoma family of tumors. *Adv Anat Pathol* 2005;12:212–20.
16 de Alava E, Gerald WL. Molecular biology of the Ewing's sarcoma/ primitive neuroectodermal tumor family. *J Clin Oncol* 2000;18:204–13.
17 Khosla D, Rai B, Patel FD, *et al*. Primitive neuroectodermal tumor of the uterine cervix diagnosed during pregnancy: a rare case with review of literature. *J Obstet Gynaecol Res* 2014;40:878–82.
18 Al-Nueimy WT, Mahmood SM. Primitive neuroectodermal tumor of the cervix uteri: a case report. *Jordan Med J* 2014;48:285–91.
19 Pauwels P, Ambros P, Hattinger C, *et al*. Peripheral primitive neuroectodermal tumour of the cervix. *Virchows Arch* 2000;436:68–73.
20 Cenacchi G, Pasquinelli G, Montanaro L, *et al*. Primary endocervical extraosseous Ewing's sarcoma/PNET. *Int J Gynecol Pathol* 1998;17:83–7.
21 Masoura S, Kourtis A, Kalogiannidis I, *et al*. Primary primitive neuroectodermal tumor of the cervix confirmed with molecular analysis in a 23-year-old woman: a case report. *Pathol Res Pract* 2012;208:245–9.
22 Mashriqi N, Gujjarlapudi JK, Sidhu J, *et al*. Ewing's sarcoma of the cervix, a diagnostic dilemma: a case report and review of the literature. *J Med Case Rep* 2015;9:255.

23 Sato S, Yajima A, Kimura N, *et al*. Peripheral neuroepithelioma (peripheral primitive neuroectodermal tumor) of the uterine cervix. *Tohoku J Exp Med* 1996;180:187–95.
24 Horn LC, Fischer U, Bilek K. Primitive neuroectodermal tumor of the cervix uteri. A case report. *Gen Diagn Pathol* 1997;142:227–30.
25 Tsao AS, Roth LM, Sandler A, *et al*. Cervical primitive neuroectodermal tumor. *Gynecol Oncol* 2001;83:138–42.
26 Malpica A, Moran CA. Primitive neuroectodermal tumor of the cervix: a clinicopathologic and immunohistochemical study of two cases. *Ann Diagn Pathol* 2002;6:281–7.
27 Snijders-Keilholz A, Ewing P, Seynaeve C, *et al*. Primitive neuroectodermal tumor of the cervix uteri: a case report—changing concepts in therapy. *Gynecol Oncol* 2005;98:516–19.
28 Goda JS, Nirah B, Mayur K, *et al*. Primitive neuroectodermal tumour of cervix: a rare entity. *Internet J Radiol* 2006;6. http://ispub.com/IJRA/6/1/12911 (accessed 22 Feb 2016).
29 Farzaneh F, Rezvani H, Boroujeni PT, *et al*. Primitive neuroectodermal tumor of the cervix: a case report. *J Med Case Rep* 2011;5:489.
30 Benbrahim Z, Haie-Meder C, Duvillard P, *et al*. Primitive neuroectodermal tumor of the cervix uteri: a case report and review of literature. *Int J Hematol Oncol Stem Cell Res* 2015;6:30–2.
31 Arora N, Kalra A, Kausar H, *et al*. Primitive neuroectodermal tumour of uterine cervix—a diagnostic and therapeutic dilemma. *J Obstet Gynaecol* 2012;32:711–13.
32 Li B, Ouyang L, Han X, *et al*. Primary primitive neuroectodermal tumor of the cervix. *Onco Targets Ther* 2013;6:707–11.
33 Xiao C, Zhao J, Guo P, *et al*. Clinical analysis of primary primitive neuroectodermal tumors in the female genital tract. *Int J Gynecol Cancer* 2014;24:404–9.