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# Gynecologic large cell neuroendocrine carcinoma: A review

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## Abstract

Large cell neuroendocrine carcinomas (LCNEC) are rare, aggressive high-grade neuroendocrine neoplasms within the neuroendocrine cell lineage spectrum. This manuscript provides a detailed review of published literature on LCNEC of gynecological origin. We performed a PubMed search for material available on gynecologic LCNEC. We analyzed 104 unique cases of gynecologic LCNECs, of which 45 were cervical primary, 45 were ovarian, 13 were uterine, and 1 was vaginal. A total of 45 cases of cervical LCNEC were identified with a median age of 36 years. Median overall survival was 16 months. We identified 45 ovarian LCNEC cases in the published literature with a median age of 54 years. Median overall survival was 8 months. 13 LCNEC cases of uterine origin were identified; 12 out of 13 were of endometrial origin and the median age was 71 years. The majority of patients presented with Stage III/IV disease (stages I–IV were 31%, 8%, 38%, and 23%, respectively). Gynecologic LCNEC is an aggressive malignancy. Our current understanding of the disease biology is very limited. Efforts are required to better understand the genomic and molecular characterizations of gynecological LCNEC. These efforts will elucidate the underlying oncogenic pathways and driver mutations as potential targets.

## Keywords

Large cell neuroendocrine carcinoma, gynecologic LCNEC literature review, PubMed search

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## Introduction

Neuroendocrine tumors (NETs) are rare tumors that originate in cells of neuroendocrine lineage. NETs are classified pathologically by their grade as well as their differentiation; therefore, the tumor types within this lineage range from low to high grade but also from well differentiated to poorly differentiated.[1] High-grade neuroendocrine neoplasms, in particular, are a group of heterogeneous malignancies that can originate in any part of the body. Large cell neuroendocrine carcinoma (LCNEC) is an aggressive subtype of high-grade neuroendocrine neoplasm. The most common site of origin for LCNEC is the thorax; however,

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it has been reported in the gastrointestinal tract, biliary tract, urogenital region, head, neck and the gynecologic tract among others. Diagnosis depends on a definite pathology because prognosis and treatment varies drastically between LCNEC and well-differentiated neuroendocrine tumors. LCNEC pathology is characterized by an organoid, trabecular, or cordlike growth pattern interspersed by peripheral palisading, rosette clusters, and geographic necrosis.[2] There is also a high mitotic rate with a predominance of large cells with large vesicular nuclei and prominent nucleoli.[2] The growth pattern for LCNEC follows peripheral palisading and necrosis to a variable extent. LCNEC is usually argyrophilic and normally shows positive reactivity for synaptophysin, CD56, or chromogranin.[3] Chromogranin is a sensitive and specific serum marker for low-grade neuroendocrine tumors, however its utility is limited in high-grade neuroendocrine carcinomas (NEC).[4] Anecdotal reports suggest that neuron-specific enolase is a sensitive tumor marker for LCNEC and other high-grade NEC, however NET/NEC serum tumor markers suffer from lack of specificity and high variability and cannot be considered diagnostic.[5] Furthermore, adenocarcinoma, squamous cell carcinoma or small cell carcinoma can coexist with LCNECs.[6] As there are many cell types in the female gynecologic tract, this large cell pathology is often misdiagnosed. Regarding the prevalence of human papilloma virus (HPV) in gynecologic LCNEC, the presence of HPV has been demonstrated in most reported cases of LCNEC, ranging from 53% to 100% with the most common strains of virus being HPV16 and HPV18.[7]

This manuscript provides a detailed review of published literature on LCNEC of gynecological origin. We discuss the results and provide a management strategy for these very rare malignancies.

## Methods

We performed a PubMed search for material available on gynecologic LCNEC. Search words included: "management of large cell neuroendocrine carcinoma" and "large cell neuroendocrine carcinoma," which resulted in 181 and 1969 publications, respectively. After additional filtering using the terms "gynecologic," "cervix," "ovary" and "uterus," 53 publications were reviewed. Of these, 29 pertinent manuscripts were identified for detailed review after removal of manuscripts not discussing case reports or not including relevant information necessary for this review.

## Results

*Cervical LCNEC*: A total of 45 cases of cervical LCNEC were identified, with a median age of 36 years (range 21–75 years). Our summary of cervical LCNEC is reported in Table 1. The median age at presentation was 36 years (range 21–75). Patients were staged I (51%), II (22%), III (9%), and IV (9%), therefore most were early stage. The remaining four patients (9%) did not have a stage identified. Of the 45 patients, 76% received surgery management, with most receiving either radical or total abdominal hysterectomy. In this cohort, 69% of patients received systemic platinum-based chemotherapy and 47% of patients received radiation therapy. Outcomes varied significantly. Mortality related to cervical LCNEC was reported as 47% at the time of publication. Survival ranged from 2 weeks post-operative to 44 months. Median overall survival (OS) was 16 months; per stage median survival was 18.5, 12, 21, and 1 month for stages I, II, III, and IV, respectively. For the stage III disease cohort, Tangjitgamol et al. reported a case with a 44-month survival, thus explaining the increased survival.[8] Survival ranged from 0.5 to 151 months (no survival data was available for 11% of patients).

*Ovarian LCNEC*: We identified 45 unique ovarian LCNEC cases in the published literature, and these are summarized in Table 2. The median age at presentation was 54 years. Epithelial components that were associated with these malignancies included mucinous borderline tumor, mucinous adenocarcinoma, mucinous adenoma/cystadenoma, endometrioid adenocarcinoma and those with mixed or otherwise unspecified features. The majority of ovarian LCNECs were unilateral. Most patients were diagnosed at an early stage with stages I, II, III, and IV at 33%, 7%, 22%, and 24%, respectively. The remaining six patients did not have a stage reported. Of significance, all patients received surgery and 87% also received chemotherapy. In this cohort, of the 39 patients that received some form of chemotherapy; 34 received platinum-based therapy and the remaining five did not specify the form of chemotherapy. At publication, 56% of patients had died of the disease. Median overall survival was 8 months; stratified OS for stages I to IV was 9.5, 22.5 ($n = 3$ for this group), 8 and 8 months, respectively. Outcome data was not available for two patients. Stage II disease represents 3 of the 45 cases; survival of one case was not available. Oshita et al. reported a survival of 40 months in one patient with stage II disease, thus explaining the increased median survival of this cohort.[9] Of all the patients, survival ranged from 0 to 68 months.

*Uterine/Vaginal LCNEC*: We found 13 LCNEC cases of uterine origin as described in Table 3; 12 of the 13 were endometrial in origin and the remaining one was of uterine corpus origin. Median age at presentation was 71 years. Unlike previous cohorts, the majority of patients presented with stage III/IV disease. The percentage among stages I-IV were 31%, 8%, 38%, and 23%, respectively. 12 patients (92%) received surgery and 6 (46%) received chemotherapy. For the patients that received chemotherapy, a platinum-based therapy was employed in all cases; three patients received carboplatin plus etoposide, two patients received cisplatin + irinotecan, and one patient received carboplatin + paclitaxel. In this cohort, 6 of 13 patients received radiation therapy. The percentage of patients with

**Table 1.** Cervical large cell neuroendocrine carcinomas reported in the literature.

| Origin | Presentation | Age | Stage | Surgery | Treatment | Response (duration) | Authors (Reference) |
|---|---|---|---|---|---|---|---|
| Cervix | Post-fibroid myomectomy surgery | 48 | IV | None | RT, nivolumab + sandostatin | AWD (12 months) | Shahabi et al.[4] |
| Cervix | Routine screening | 27 | IA | Radical abdominal trachelectomy, PLD | Cisplatin + etoposide | NED (6 months) | Rajkumar[25] |
| Cervix | N/A | 30 | IIB | None | RT and brachytherapy; Etoposide + cisplatin | NED (23 months) | Li[26] |
| Cervix | Vaginal bleeding | 31 | IB | TAH, BSO | RT, chemo | AWD (151 months) | Sato et al.[17] |
| Cervix | Vaginal bleeding | 34 | IB | TAH, BSO | RT, chemo | DOD (19 months) | Sato et al.[17] |
| Cervix | Vaginal bleeding | 27 | IB | TAH, BSO | RT, chemo | DOD (16 months) | Sato et al.[17] |
| Cervix | Vaginal bleeding | 51 | IB | TAH, BSO | RT, chemo | DOD (16 months) | Sato et al.[17] |
| Cervix | Abnormal Pap | 47 | IB | TAH, BSO | RT, chemo | NED (12 months) | Sato et al.[17] |
| Cervix | Abnormal Pap | 42 | IIA | TAH, BSO | RT, chemo | DOD (6 months) | Sato et al.[17] |
| Cervix | N/A | 31 | IA | RH | NFT | NED (10 months) | Yun[27] |
| Cervix | Atypical vaginal bleeding | 40 | IB | TAH, BSO, PLD | NFT | NED (9 months) | Kawauchi[28] |
| Cervix | Vaginal spotting | 47 | IIA | RH, PPALD | RT and brachytherapy (patient could not afford chemo) | NED (6 months) | Cetiner et al.[12] |
| Cervix | Screening Pap | 25 | IB1 | RH, PPALD | *INITIAL*: Etoposide + cisplatin; *RECURRENCE*: Vincristine, adriamycin + cytoxan; carboplatin + etoposide; *THEN*: Topotecan; *THEN*: Paclitaxel; *THEN*: Protein kinase C inhibitor | Initial partial response then DOD (35 months) | Krivak et al.[15] |
| Cervix | Post-coital bleeding | 36 | IIA | None | RT, concurrent etoposide + cisplatin | Progression, DOD (33 months) | Krivak et al.[15] |
| Cervix | Vaginal bleeding most common | 55 | IIB | None | NFT | AWD (1 months) | Rhemtula[29] |
| Cervix | N/A | 75 | IIIB | None | RT | DOD (3 months) | Rhemtula[29] |
| Cervix | N/A | 51 | IVB | None | NFT | DOD (0.5 months) | Rhemtula[29] |
| Cervix | N/A | 65 | IVB | None | RT | DOD (1 months) | Rhemtula[29] |
| Cervix | N/A | 42 | N/A | None | NFT | N/A | Rhemtula[29] |
| Cervix | Vaginal bleeding | 51 | IIA2 | RH, BSO, bilateral PLD | Irinotecan + cisplatin prior to surgery cisplatin | NED (21 months) | Omori et al.[7] |
| Cervix | Post-coital bleeding | 31 | N/A | RH | Cisplatin + irinotecan | NED (15 months) | Tanimoto[30] |
| Cervix | 6 week post-partum check | 33 | IB | RH, BSO, PPALD | Cisplatin + etoposide | NED (24 months) | Yoseph[31] |
| Cervix | N/A | 37 | IIIB | Unknown | Unknown | DOD (21 months) | Kajiwara et al.[18] |
| Cervix | N/A | 55 | IIA | Unknown | Unknown | DOD (12 months) | Kajiwara et al.[18] |
| Cervix | N/A | 38 | IB | TAH, BSO | Chemo + radio-chemo | AWD (21 months) | Baykal[32] |
| Cervix | Pelvic pain and vaginal bleeding | 31 | IIIB | TAH, BSO, PPALD | Chemo, RT | N/A | Powell[33] |
| Cervix | N/A | 60 | N/A | RH | Chemo, RT | DOD (18 months) | Markapoulos[34] |
| Cervix | N/A | 40 | IVB | None | Platinum based chemo | N/A | Brown[35] |
| Cervix | Abnormal Pap | 24 | IB2 | TAH | Concurrent cisplatin + RT; *THEN*: Etoposide + cisplatin + doxorubicin; *THEN*: Oral etoposide; Brachytherapy also used | NED (47 months) | Embry et al.[14] |

*(Continued)*

**Table 1.** (Continued)

| Origin | Presentation | Age | Stage | Surgery | Treatment | Response (duration) | Authors (Reference) |
|---|---|---|---|---|---|---|---|
| Cervix | Abnormal Pap | 36 | IA2 | RH | NFT | NED (36 months) | Gilks et al.[16] |
| Cervix | Abnormal Pap | 35 | IB | RH | Etoposide + cisplatin + RT | DOD (18 months) | Gilks et al.[16] |
| Cervix | Abnormal Pap | 33 | IB | RH | Chemo | DOD (8 months) | Gilks et al.[16] |
| Cervix | Vaginal bleeding | 31 | IB | RH | Chemo | NED (36 months) | Gilks et al.[16] |
| Cervix | Vaginal bleeding | 62 | IIA | RH | NFT | DOD (6 months) | Gilks et al.[16] |
| Cervix | Vaginal bleeding | 38 | IA2 | RH | N/A | LFU | Gilks et al.[16] |
| Cervix | Vaginal bleeding | 31 | IB | RH | Adriamycin, vincristine, cyclophosphamide | DOD (12 months) | Gilks et al.[16] |
| Cervix | N/A | 29 | IB | RH | NFT | DOD (24 months) | Gilks et al.[16] |
| Cervix | N/A | 36 | IB | RH | Cisplatin, etoposide, RT | DOD (24 months) | Gilks et al.[16] |
| Cervix | N/A | 21 | IB | RH | Cisplatin, etoposide, adriamycin | DOD (10 months) | Gilks et al.[16] |
| Cervix | N/A | 29 | IB | RH | Cisplatin, etoposide, adriamycin | NED (30 months) | Gilks et al.[16] |
| Cervix | N/A | 25 | IB | RH | Carboplatin, etoposide | NED (6 months) | Gilks et al.[16] |
| Cervix | Vaginal bleeding | 37 | N/A | RH | Chemo, RT | N/A | Niwa[36] |
| Cervix | N/A | 42 | III | Extrafascial hysterectomy, BSO, and partial OMY | Paclitaxel + carboplatin (patient declined RT); *RECURRENCE*: Re-induction paclitaxel carboplatin, then cisplatin and etoposide | DOD (44 months) | Tangjitgamol et al.[8] |
| Cervix | Abnormal Pap | 45 | IIB | RH, BSO and PLD | RT, brachytherapy, and concurrent cisplatin | NED (unknown) | Dikmen[37] |
| Cervix | Post-coital vaginal bleeding | 35 | IIB | TAH, RSO | Cyclophosphamide, adriamycin, cytoxan, cisplatin, etoposide, RT adjuvant therapy with ifosfamide, cisplatin, and etoposide | DOD (19 months) | Tsou et al.[1] |

AWD: alive with disease; BSO: bilateral salpingo-oophorectomy; Chemo: non-specified chemotherapy; DOD: dead of disease; LFU: lost to follow up; N/A: not available; NED: no evidence of disease; NFT: no further treatment; OMY: omenectomy; PLD: pelvic lymph node dissection; PPALD: pelvic and para-aortic lymph node dissection; RH: radical hysterectomy; RSO: right salpingo-oophorectomy; RT: radiation therapy; TAH: total abdominal hysterectomy.

uterine LCNEC that died of disease was 46%. Median OS was 7.5, 23 ($n = 1$), 10 and 1 month for stages I-IV, respectively, with survival ranging from 1 month to 23 months. Jin et al. reported one case of a 53-year-old female that was diagnosed with stage IV vaginal LCNEC. She was treated with palliative chemotherapy and radiation and was alive with disease at 12 months.[10]

Tables 1–3 summarize the individual case-based data for cervical, ovarian, uterine and vaginal LCNEC, respectively.

## Discussion

Neuroendocrine neoplasms of the gynecologic tract are particularly uncommon with NETs of the uterus or cervix representing 0.9% to 1.5% of the tumors and accounting for 100 to 200 diagnoses yearly in the United States.[11] Furthermore, with the potential ambiguity surrounding the diagnostic criteria, some LCNEC cases may have been inaccurately classified as undifferentiated or poorly differentiated adenocarcinoma. Large cell carcinomas of the gynecologic tract are especially aggressive, tend to recur, and there is limited data regarding the natural history, progression, and management of the disease. Due to the rare nature of the disease, it is challenging to determine an optimal therapy by utilizing randomized controlled trials, but it has been proposed that these patients could be treated similar to those with small-cell neuroendocrine carcinoma because of similar malignant potential and platinum sensitivity.[12] For therapeutic intervention, a multi-modality approach should be undertaken.

For our review, the 104 unique cases of gynecologic LCNECs were positive for neuroendocrine markers, such as chromogranin A, CD56 and synaptophysin. Of the 45 cases of LCNEC of the cervix, an abnormal screening Papanicolaou smear and vaginal bleeding were the most common reasons for presentation. For the majority of ovarian LCNEC cases, abdominal pain and/or abdominal distention were the reasons for presentation, whereas post-menopausal bleeding was the most common reason for presentation for endometrial and uterine LCNEC. The

**Table 2.** Ovarian large cell neuroendocrine carcinomas reported in the literature.

| Origin (and associated cells) | Presentation | Age | Stage | Surgery | Treatment | Response (Duration) | Authors [Reference] |
|---|---|---|---|---|---|---|---|
| Ovary | Abdominal pain and amenorrhea | 35 | IIIC | TAH, BSO | NFT | AWD (3 months) | Agarwal[38] |
| Ovary – AdCa | Abdominal distention and pain | 68 | IV | TAH, BSO, OMY, PPALD | Etoposide + cisplatin | DOD (7 months) | Cokmert[39] |
| Ovary – Undifferentiated Non-Small Cell | Abdominal distention | 77 | IV | Surgical debulking | Etoposide + carboplatin | Died (1.5 months) | Ki[40] |
| Ovary – Undifferentiated Non-Small Cell | Abdominal discomfort | 58 | IA | TAH, BSO, OMY, PLD | *INITIAL*: Cisplatin + paclitaxel; *RECURRENCE*: Docetaxel | DOD (17 months) | Ki[40] |
| Ovary | Urinary frequency | 67 | IIB | TAH, BSO, OMY, PPALD | Carboplatin + paclitaxel | AWD (5 months) | Ki[40] |
| Ovary – Mucinous Adenoma | Abdominal distention | 50 | IA | TAH, BSO, OMY + PLD | *INITIAL*: Cisplatin + etoposide; *RECURRENCE*: Paclitaxel + carboplatin | DOD (7 months) | Asada[41] |
| Ovary – Pure | Abdominal distention, pain, fever, itching | 40 | IIIC | BSO, OMY, PPALD 9 mo after laparoscopic type I hysterectomy, bilateral PLD | Etoposide + cisplatin | NED (6 months) | Shakuntala[42] |
| Ovary – Pure | Pelvic mass | 27 | IC | LSO, OMY | Chemo | NED (10 months) | Behnam[43] |
| Ovary | Abdominal pain | 76 | N/A | TAH, BSO, OMY | NFT | Died post-op | Aslam[44] |
| Ovary – Pure | Abdominal distention | 46 | IIIC | Subtotal abdominal hysterectomy, BSO, OMY | Paclitaxel + carboplatin | DOD (4 months) | Tsuji et al.[11] |
| Ovary | Abdominal distention | 35 | N/A | TAH, BSO, OMY | Chemo | DOD (4 months) | Kim |
| Ovary – Pure | Abdominal discomfort | 64 | IA | TAH, BSO + OMY | Bleomycin, cisplatin + etoposide; Bleomycin discontinued due to development of side effects | NED (9 months) | Lindboe[45] |
| Ovary – Serous AdCa | Abdominal pain and distention | 71 | IIIB | TAH, BSO | Taxol + carboplatin | NED (8 months) | Choi[46] |
| Ovary – Mucinous AdCa | N/A | 58 | IIIB | TAH, BSO, OMY | Chemo | DOD (8 months) | Eichorn[47] |
| Ovary – Endometroid AdCa | N/A | 77 | IA | RSO, prior TAH | RT | DOD (19 months) with Mets | Eichorn[47] |
| Ovary – Mucinous AdCa | N/A | 36 | IA | TAH, BSO | N/A | Unknown | Eichorn[47] |
| Ovary – Mucinous AdCa | N/A | 45 | IB | TAH, BSO, OMY | Chemo | DOD (36 months) | Eichorn[47] |
| Ovary – Mucinous AdCa | N/A | 68 | IIB | TAH, BSO, OMY | N/A | Unknown | Eichorn[47] |
| Ovary – Mucinous AdCa | N/A | 73 | IIIC | Prior TAH, BSO, OMY | Paclitaxel, cisplatin, adriamycin | DOD (8 months) | Chen[20] |
| Ovary – Mucinous Intraepithelial AdCa | N/A | 44 | IA | TAH, BSO, OMY | Paclitaxel, carboplatin | DOD (4 months) | Chen[20] |
| Ovary – Mucinous AdCa + Teratoma | Abdominal mass | 53 | IV | TAH, BSO, OMY, PLD | Carboplatin + paclitaxel | DOD (3 months) | Chenevert[48] |
| Ovary – Mucinous AdCa + Teratoma | Abdominal distention | 53 | I | TAH, BSO, OMY | Cisplatin + etoposide | DOD (7 months) | Chenevert[48] |
| Ovary – Serous AdCa | Abdominal distention and ascites | 68 | IV | TAH, BSO, OMY, debulking | Carboplatin + paclitaxel | DOD (7 months) | Draganova-Tacheva[49] |
| Ovary – Mucinous | Abdominal pain | 39 | IV | TAH, BSO | Cisplatinum-based chemo | AWD (8 months) | Veras et al.[23] |
| Ovary – Mucinous | Abdominal pain | 55 | I | TAH, BSO | Cisplatinum-based chemo | NED (68 months) | Veras et al.[23] |

*(Continued)*

**Table 2.** (Continued)

| Origin (and associated cells) | Presentation | Age | Stage | Surgery | Treatment | Response (Duration) | Authors [Reference] |
|---|---|---|---|---|---|---|---|
| Ovary – none | Pelvic pain | 42 | IV | TAH, BSO | Cisplatinum-based chemo | DOD (20 months) | Veras et al.[23] |
| Ovary – Endometroid Ca | Ascites | 53 | III | TAH, BSO | Cisplatinum-based chemo | NED (37 months) | Veras et al.[23] |
| Ovary – AdCa and Mature Teratoma | Abdominal bloating | 47 | III | TAH, BSO | Cisplatinum-based chemo | NED (11 months) | Veras et al.[23] |
| Ovary – Mature Cystic Teratoma | Abdominal pain | 25 | IV | BSO, OMY, APPY | Cisplatinum-based chemo | DOD (36 months) | Veras et al.[23] |
| Ovary – Mucinous LMP | Vaginal bleeding | 55 | III | TAH, BSO | Cisplatinum-based chemo | DOD (2 months) | Veras et al.[23] |
| Ovary – Mucinous and Endometroid Ca | Pelvic mass | 54 | I | TAH, BSO | Cisplatinum-based chemo | **NED (66 months)** | **Veras et al.**[23] |
| Ovary – Endometroid | Ascites | 63 | IV | TAH, RSO | Cisplatinum-based chemo | DOD (9 months) | Veras et al.[23] |
| Ovary – AdCa | Abdominal pain | 59 | I | BSO | Cisplatinum-based chemo | NED (28 months) | Veras et al.[23] |
| Ovary – Mucinous Ca | Abdominal pain | 22 | I | RSO, APPY | Cisplatinum-based chemo | DOD (3 months) | Veras et al.[23] |
| Ovary – Mucinous Intraepithelial Ca | Abdominal distention and weight loss | 36 | N/A | TAH, BSO, OMY, PLD | Chemo | NED (6 months) | Yasuoka[50] |
| Ovary – Mucinous Cystadenoma | Abdominal distention | 65 | N/A | TAH, BSO, OMY, PLD, APPY | NFT | DOD (10 months) | Jones[51] |
| Ovary – Mucinous Cystadenoma and Mucinous AdCa | Abdominal distention | 34 | IC | TAH, BSO, OMY | Cisplatinum + cyclophosphamide | DOD (8 months) | Collins et al.[21] |
| Ovary – Endometrioid Adca | Abdominal pain, fatigue | 33 | N/A | LSO, partial OMY; *THEN*: TAH, RSO, PPALD | Irinotecan + nedaplatin | DOD (4 months) | Ohira[52] |
| Ovary – Pure | Dysarthria | 73 | IV | TAH with bilateral adnexectomy, left-sided nephrectomy, OMY | Carboplatin + paclitaxel | NED (12 months) | Dundr et al.[22] |
| Ovary- Pure | Asymptomatic pelvic mass | 66 | IV | TAH, BSO, OMY | *INITIAL*: Carboplatin + paclitaxel<br>*RECURRENCE*: Brain RT | NED (64 months) | Oshita et al.[9] |
| Ovary – Endometroid AdCa | Asymptomatic pelvic mass | 80 | IIC | TAH, BSO, PLD, OMY, APPY | Carboplatin + paclitaxel | NED (40 months) | Oshita et al.[9] |
| Ovary – Endometroid AdCa | Abdominal pain | 65 | IC | TAH, BSO, OMY | Carboplatin + paclitaxel | DOD (2 months) | Oshita et al.[9] |
| Ovary –Endometroid AdCa | Abdominal mass | 42 | IIIB | TAH, BSO, peritoneum resection of Douglas pouch, OMY, PLD | Carboplatin + paclitaxel | NED (32 months) | Oshita et al.[9] |
| Ovary – Pure | Abdominal pain and distention | 40 | N/A | BSO, OMY, sigmoid colon debulking | Etoposide + cisplatin | NED (6 months) | **Shakuntala**[42] |
| Ovary – Mature Cystic Teratoma | Unknown | 69 | IV | debulking | Paclitaxel + carboplatin | DOD (6 months) | Miyamoto[53] |

AdCa: adenocarcinoma; APPY: appendectomy; AWD: alive with disease; BSO: bilateral salpingo-oophorectomy; Ca: carcinoma; Chemo: non-specified chemotherapy; DOD: dead of disease; LMP: low malignant potential; LSO: left salpingo-oophorectomy; Mets: metastases; N/A: not available; NED: no evidence of disease; NFT: no further treatment; OMY: omenectomy; PLD: pelvic lymph node dissection; PPALD: pelvic and para-aortic lymph node dissection; RSO: right salpingo-oophorectomy; RT: radiation therapy; TAH: total abdominal hysterectomy.

**Table 3.** Endometrial, uterine corpus and vaginal large cell neuroendocrine carcinoma reported in the literature.

| Origin (plus associated cells) | Presentation | Age | Stage | Surgery | Treatment | Response (duration) | Authors (Reference) |
|---|---|---|---|---|---|---|---|
| Endometrium – Pure | Postmenopausal vaginal bleeding | 71 | IVB | RH, BSO, OMY, PPALD | NFT | DOD (1 months) | Nguyen et al.[5] |
| Endometrium – Sarcomatoid | Abnormal uterine bleeding | 40 | IB | TAH, BSO, OMY, PLD | NFT | AWD (16 months) | Terada[54] |
| Endometrium – Pure | N/A | 50 | IIIC | TAH, BSO, OMY | RT, cisplatin, etoposide | AWD (12 months) | Mulvany[55] |
| Endometrium – Endometroid | N/A | 80 | IC | TAH, BSO | NFT | DOD (5 months) | Mulvany[55] |
| Endometrium – Endometroid | N/A | 77 | IIB | TAH, BSO | RT | DOD (23 months) | Mulvany[55] |
| Endometrium – Endometroid | N/A | 79 | IIIA | TAH, BSO, Omental biopsy | RT | AWD (2 months) | Mulvany[55] |
| Endometrium – Endometroid | N/A | 88 | IIIC | TAH, BSO, LN biopsy | RT | AWD (1 months) | Mulvany[55] |
| Endometrium | Abdominal distention | 73 | IVB | None | Patient refused | DOD (1 months) | Makihara[34] |
| Endometrium | Vaginal bleeding | 73 | IIIC | TAH, BSO, OMY, PPALD | Cisplatin + irinotecan | AWD (13 months) | Makihara[34] |
| Endometrium | Postmenopausal bleeding | 59 | IV | TAH, BSO, OMY, PPALD | Carboplatin + paclitaxel with RT and brachytherapy; *THEN*: Pegylated doxorubicin followed by etoposide, cisplatin and LAR | DOD (12 months) | Shahabi et al.[4] |
| Endometrium – Pure | Post-menopausal bleeding | 70 | IB | TAH, BSO, OMY | Cisplatin + etoposide | NED (6 months) | Deodhar[56] |
| Endometrium – Pure | N/A | 42 | IC | RH | Cisplatin + etoposide | AWD (9 months) | Albores-Saavedra et al.[3] |
| Uterine Corpus – Pure | Lower abdominal pain | 52 | IIIC2 | TAH, BSO, PPALD | *INITIAL*: Irinotecan + cisplatin with RT *PROGRESSION*: RT, paclitaxel + carboplatin | DOD (10 months) | Kobayashi et al[24] |
| Vagina | Pelvic pain and difficulty voiding | 53 | IV | None | Palliative radiation + chemo | AWD (12 months) | Jin et al.[10] |

AWD: alive with disease; BSO: bilateral salpingo-oophorectomy; Chemo: chemotherapy; DOD: dead of disease; LAR: long acting-release octreotide; LN: lymph node; N/A: not available; NED: no evidence of disease; NFT: no further treatment; OMY: omenectomy; PLD: pelvic lymph node dissection; PPALD: pelvic and para-aortic lymph node dissection; RH: radical hysterectomy; RT: radiation therapy; TAH: total abdominal hysterectomy.

one case of LCNEC of the vagina reported by Jin et al. was of a 53-year-old female who presented with metastatic stage IV disease.[10]

LCNEC of the gynecologic tract has a poor prognosis, especially for patients that present in an advanced stage. A variety of therapeutic regimens exist with attention toward a multimodality approach, including combinations of surgery, chemotherapy and radiation. This multimodal approach is supported by both the Society of Gynecologic Oncology and the Gynecologic Cancer Intergroup.[13] Survival outcome is variable and dependent on both stage at diagnosis and response to the treatment. Embry et al. reported that earlier stage ($p < 0.00001$) and the addition of chemotherapy ($p = 0.04$) were associated with improved survival for cervical LCNECs.[14] They also reported platinum agents ($p = 0.034$) and platinum+etoposide ($p = 0.027$) were associated with improved survival.[14] Furthermore, for LCNECs with metastatic lesions, long-term survival is uncommon.[15] Because of the rarity of these malignancies, management is often extrapolated from small and large cell carcinomas of the lung. Adjuvant chemotherapy with cisplatin, carboplatin, etoposide or cyclophosphamide has been used in the management of LCNEC of the lung, and is very frequently used in LCNEC of the gynecologic tract as well.[4]

## Cervix

Our 45 cases of cervical LCNEC summarized in Table 1 include patients with all stages of disease as well as a wide range of survival (0.5 months to 151 months). Treatment included surgery, chemotherapy, and/or radiation, with a majority (76%) receiving surgery. Of note, Embry et al. reported 62 cases of cervical LCNEC; importantly, the authors documented a similar median age to ours (37 years) with the identical age range of 21 to 75. Furthermore, a majority of their patients also had stage I disease. Of these cases, 73% underwent primary surgery, 4.7% underwent primary radiation, 4.7% underwent chemotherapy and 8% had chemoradiation. There were 9.6% with no primary treatment. Reported patient outcomes were as follows: 58% died of disease, 26% had no evidence of disease, 3% were alive with disease and 13% had no survival data. Multivariate analysis revealed that earlier stage ($p < 0.00001$) and the addition of chemotherapy ($p = 0.04$) particularly platinum agents ($p = 0.034$) and the platinum+etoposide combination ($p = 0.027$) were associated with improved survival.[14]

For early stage cervical LCNEC, therapy should begin with radical hysterectomy, bilateral salpingo-oophorectomy, and pelvic lymphadenectomy. Gilks et al. reported a case of a 36-year-old patient with stage I disease who had no evidence of it 36 months after a radical hysterectomy.[16] However, the current recommendation is to follow surgery with chemoradiation, cisplatin (platinum-based therapy) and etoposide.[13] Of note, this therapy is based on regimens used in small cell lung cancer as there are no prospective phase II or phase III clinical trials evaluating anti-tumor efficacy in gynecologic LCNEC. However, prophylactic brain irradiation is not recommended in these patients as it is with small cell lung cancer.

For locally advanced disease in women with neuroendocrine carcinoma (stage IB2–IVA disease), concurrent chemradiation followed by additional chemotherapy with intent to cure should be the treatment plan. The ideal regimen is the same as that described above, with cisplatin and etoposide given on a 3-week cycle. Sato et al. implemented chemotherapy (specific therapy not identified) with concurrent radiation therapy after a total abdominal hysterectomy and bilateral oophorectomy in a 31 to year-old patient with stage 1B disease; this patient was reported to be alive with disease at 151 months.[17] For patients with no evidence of intraperitoneal spread and nodal metastatic burden, neoadjuvant chemotherapy with cisplatin and etoposide followed by consolidation radiation therapy may be of some benefit.[13] However, per our analysis, LCNEC remains a disease with poor prognosis, with a median OS of less than 2 years.

Hormone receptor and growth factor receptor expression could have a role in predicting survival in cervical LCNEC. Tangjitgamol et al. performed this evaluation for cervical LCNEC and identified a significantly shorter OS in patients with a HER-2 neu negative status as compared to those with positive HER-2 neu tumors (median OS: 14.2 vs 33.1 months), and a trend towards a worse OS in patients positive for epidermal growth factor receptor.[8] The group concluded that the combination of negative HER-2 neu status and positive epidermal growth factor receptor expression impaired OS.[8]

There is a potential role for targeted therapy in cervical LCNEC. Somatostatin receptors are profusely expressed in low-grade NETs, and some somatostatin receptor binding is generally observed in high-grade NEC. Hence targeted therapy with octreotide, a somatostatin analog, could be explored as suggested by Shahabi et al. Potential mechanisms by which octreotide could inhibit tumor growth include inhibition of growth hormone secretion, such as IGF-1, inhibition of angiogenesis, and through direct action on the tumor.[4] Kajiwara et al. also proposed using octreotide to treat neuroendocrine tumors, since 3 out of 7 cases (2 of 5 small cell carcinomas and 1 of 2 LCNEC) expressed somatostatin receptor type 2A.[18] However, a larger study is needed to validate these conclusions. Many clinicians are skeptical of the role for somatostatin analog in LCNEC management.

The role of radiation therapy should be strongly considered, especially with the addition of brachytherapy in the setting of LCNEC of the cervix. Robin et al. found a significant improvement in OS when brachytherapy and external beam radiation therapy were combined. They identified 100 patients with locally advanced non-metastatic neuroendocrine cervical cancer (included both large cell and small cell) that were treated with definitive chemoradiotherapy between 2004 and 2012. There was a substantial improvement in OS when brachytherapy was administered in addition to external beam radiotherapy. By multivariate analysis, an improved median survival of 48.6 versus 21.6 months (95% CI, 0.255–0.883; $p = 0.019$) was seen with the addition of brachytherapy compared to external beam radiotherapy alone. This study was performed in patients with locally advanced neuroendocrine carcinoma of the cervix, of both large and small cell etiology, treated with chemoradiotherapy.[19]

## Ovary

As evidenced by our 45 cases of ovarian LCNEC summarized in Table 2, patients with this disease unfortunately have a poor prognosis; 8 month survival was noted for those patients with both stage III and stage IV disease. Reported survival for all stages ranged from 0 to 68 months. In the 33 cases reported by Oshita et al., the 5-year survival was only 34.9%.[9] One case exhibited rapid disease progression with pelvic mass formation, liver metastasis and pelvic lymphadenopathy within 2 weeks after primary surgery, with the tumor being unresponsive to Taxol and carboplatin chemotherapy.[9] Evidence that ovarian LCNEC is an

aggressive malignancy has also been reported in other cases outlined above.[20,21] However, it is worth noting that there is evidence of success with surgery followed by adjuvant platinum-based chemotherapy. Dundr et al. reported a case of a 73-year-old with stage IV ovarian LCNEC and no evidence of the disease 12 months after undergoing surgery and chemotherapy with carboplatin and paclitaxel.[22] An anecdotal case series from MD Anderson Cancer Center reported 22 to 68 months survival in three stage I cases with standard surgery followed by adjuvant platinum-based chemotherapy.[23] Based on the above-mentioned observations, therapeutic consideration similar to primary lung LCNEC can be applied toward those of ovarian origin. This includes utilizing such regimens as cisplatin/vinorelbine, cisplatin/etoposide, cisplatin/vinblastine, cisplatin/gemcitabine and cisplatin/docetaxel in tumors that are initially unresponsive to first line taxotere and cyclophosphamide therapy.[9] In one case reported by Oshita et al., radiation was utilized for brain metastasis and the patient had no evidence of the disease for 64 months, which adds support to employing radiation in situations of local recurrence or distant metastasis.[9]

### *Uterus*

Limited data exists to guide therapy in cases of uterine LCNEC, however as mentioned above, a multi-modality approach is commonly applied. Similar to LCNEC of the cervix, tumors in the uterus, notably the endometrium, are managed initially with cytoreductive surgery. Based on prior published reports, a hysterectomy and bilateral salpingo-ophorectomy are recommended at minimum.[5] Unfortunately, a number of cases were reported with early-stage disease at the time of surgery that developed distant metastasis or rapid recurrence; therefore, omentectomy and pelvic and paraaortic lymphadenectomy should be considered for accurate staging. Of note, physicians may want to determine a patient's response to chemotherapy prior to initiating surgery, as surgery has often been shown to be of little benefit. Currently there is no consensus regarding optimal management of these tumors after surgery. In the case reports as described, adjuvant chemotherapy and/or radiation was either performed or planned in the majority of the cases. Chemotherapy, radiation or both is favored by most treating physicians. Occasionally, neoadjuvant therapy is considered in cases where LCNEC is diagnosed on a preoperative curettage, or when an endometrial biopsy specimen is done in advanced cases of ovarian cancer. Adjuvant chemotherapy generally consists of platinum and etoposide based chemotherapy as in cervical disease.[5] Shahabi et al. incorporated octreotide into their treatment regimen due to a single case report of its use for an endometrial small cell NET in which a partial response was reported; however, disease progression was observed.[4] In the one case of LCNEC of the uterine corpus, Kobayashi et al. reported a rapidly progressing stage III disease that did not respond to irinotecan/cisplatin initially but paclitaxel/carboplatin with concurrent radiation was helpful.[24]

## Conclusion

As discussed above, LCNECs are high-grade neuroendocrine carcinomas and represent a rare diagnosis, especially in sites such as the gynecologic tract. Our current understanding of the biology of this pathology is limited. As inadequate data exists regarding the treatment of this pathology, it has been demonstrated in the aforementioned cases of LCNEC in the gynecologic tract that a multimodality treatment approach including surgery, chemotherapy and radiation should be undertaken. Further efforts are required to gain more knowledge on how best to treat these aggressive malignancies.

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### Contributorship

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