Cowden Disease with Lhermitte-Duclos Disease: Case Report

Sujit S. Prabhu, Kenneth D. Aldape, Janet M. Bruner, Jeffrey S. Weinberg

ABSTRACT: Background: We report a case and review the recent literature describing 36 patients with both Lhermitte-Duclos disease (LDD) and Cowden disease (CD). Lhermitte-Duclos disease, or dysplastic gangliocytoma, is a benign hamartomatous condition involving the cerebellum. The presenting symptoms are usually headaches, gait ataxia, and symptoms of lower cranial nerve involvement. Cowden disease is a rare autosomal dominant disease that usually presents with multiple mucocutaneous lesions. Patients with CD are prone to multiple systemic malignancies, the most common of which is breast cancer. Recent studies have demonstrated an association between LDD and CD.

Methods: A 44-year-old woman with a previous history of breast cancer, multiple benign skin lesions, Hashimoto’s thyroiditis, and chronic headaches presented with exacerbation of her headaches during the previous year. Magnetic resonance imaging of the brain revealed a right cerebellar nonenhancing mass and an acquired tonsillar herniation.

Results: The patient underwent resection of the right cerebellar mass, posterior fossa decompression, C1 and C2 laminectomies, and a duraplasty. Pathologic examination confirmed LDD. The patient recovered well after surgery, with immediate improvement of her headaches.

Conclusions: The association between LDD and CD has been under-recognized and under-reported. Recognition of this association has direct clinical relevance, because diligent monitoring of individuals with LDD and CD may lead to the early detection of systemic malignancies.

RÉSUMÉ: Maladie de Cowden associée à une maladie de Lhermitte-Duclos: cas clinique et revue de la littérature. Introduction : Nous décrivons un cas clinique et nous révisons la littérature concernant 36 patients présentant une maladie de Lhermitte-Duclos (MLD) et une maladie de Cowden (MC). La MLD ou gangliocytome dysplasique est une maladie hamartomatouse bénigne du cervelet. Le patient consulte généralement pour de la céphalée, une ataxie à la marche et des symptômes en relation avec une atteinte des nerfs crâniens inférieurs. La MC est une maladie rare, dont l’héritéité est autosomique dominante, dans laquelle les patients présentent de multiples lésions mucocutanées. Les patients ayant une MC sont sujets à de multiples cancers, le plus fréquent étant le cancer du sein. Des études récentes ont montré une association entre la MLD et la MC.

Méthodes : Une femme âgée de 44 ans, ayant une histoire antérieure de cancer du sein, de multiples lésions cutanées bénignes, de thyroïdite d’Hashimoto et de céphalées chroniques a consulté pour une exacerbation de ses céphalées depuis un an. L’IRM du cerveau a montré une masse non rehaussee dans la partie droite du cervelet et une hernie amygdaloïdale acquise.

Résultats : La patiente a subi une résection de la masse cérébelleuse droite, une décompression de la fosse postérieure, des laminectomies C1 et C2, et une plastie de la dure-mère. L’analyse anatomopathologique a confirmé la présence d’une MLD. La patiente a bien récupéré de sa chirurgie avec une amélioration immédiate de ses céphalées.

Conclusions : L’association entre la MLD et la MC a été méconnue et peu rapportée. L’identification de cette association a une pertinence clinique directe puisqu’une surveillance clinique étroite des individus atteints de MLD et de MC peut permettre de détecter plus tôt la présence de cancers.


Lhermitte-Duclos disease (LDD), or dysplastic cerebellar gangliocytoma, is a benign hamartomatous tumor of the cerebellum that causes progressive cerebellar dysfunction, which is associated with raised intracranial pressure and noncommunicating hydrocephalus. The prognosis is good if the tumor is resected. In 1920, Lhermitte and Duclos first described the condition as enlarged folia containing abnormal ganglion cells in circumscribed regions of the cerebellum. Since then, approximately 80 cases have been described in the literature. The diagnosis of CD is established clinically by the presence of pathognomonic mucocutaneous lesions or by a combination of major and minor operational criteria for the diagnosis of CD established by the International Cowden Syndrome Consortium (see Table 1). Most commonly, the characteristic mucocutaneous lesions include trichilem-
momas, papillomatous papules, mucosal lesions, and acral keratosis. In 1981, Russel et al. described the simultaneous mucocutaneous signs of CD and diffuse cerebellar hypertrophy (LDD) in one patient as a coincidence. In 1991, Padberg et al. first described the association between the two conditions as a single phakomatosis in two unrelated patients.

The purpose of this report is to describe a case in which the patient had signs and symptoms of both LDD and CD and to analyze the important findings from 36 reported cases. It appears that the incidence of CD is under-reported. Neurosurgeons who treat patients with LDD should be aware of the diagnostic criteria of CD because up to 20% of patients with LDD may have signs and symptoms suggestive of CD. Also, it is very important to recognize CD as these patients have an increased risk of developing systemic malignancies and brain tumors.

**CASE REPORT**

**History and physical examination**

A 44-year-old Caucasian woman presented to the neurosurgical clinic at the University of Texas M.D. Anderson Cancer Center with a five-year history of headaches, which had been exacerbated for the previous year. She also had been diagnosed with infiltrating ductal carcinoma of the breast six years ago and had undergone bilateral mastectomies, chemotherapy, and radiation treatment. She had remained disease-free. The headaches were mainly occipital in distribution, were unrelated to posture, and were not associated with nausea or vomiting. In the past she had multiple wart-like skin lesions (one with histologic features consistent with granuloma annulare and another with features of sclerotic fibroma) and Hashimoto’s thyroiditis. Her family history was significant for two sisters with breast cancer, thyroid abnormalities and skin lesions, and father with thyroid and prostate cancer.

On physical examination, the patient was normocephalic and had normal higher-functions. Her Karnofsky performance score was 100, with no cranial nerve deficits. Her motor, sensory and cerebellar functions were normal.

Magnetic resonance imaging (MRI) of the brain revealed a nonenhancing mass in the right cerebellar hemisphere that measured 7 x 6 x 3 cm. On T1-weighted images, the lesion was hypointense non-enhancing with the administration of gadolinium (Figure 1A). The T2-weighted images showed the characteristic feature of LDD, i.e., striations representing the folia of the cerebellum (Figure 2A), along with acquired tonsillar herniation to C2, and early hydrocephalus (Figure 3A).

**Treatment and outcome**

A posterior fossa craniectomy was performed. At surgery, the right cerebellar hemisphere was swollen, and it herniated out when the dura mater was opened. The tumor and normal cerebellum were not clearly demarcated, and the resection was guided by ultrasound. After the tumor was resected, a C1 and C2 laminectomy was performed. The dura mater was opened down to C2 below the lowest level of tonsillar herniation and a patulous dural graft was placed. The patient’s symptoms improved substantially immediately after surgery and, at her four-month follow-up visit, she was asymptomatic. Postoperative MRI demonstrated gross total resection of the lesion, substantial posterior fossa decompression, and the tonsils had ascended to the level of the foramen magnum (Figures 1B, 2B, 3B).

**Histologic features**

Figure 4 shows a low-power (40x) microscopic image of the cerebellar cortex. Abnormal neurons directly under the pial surface essentially replaced the normal molecular layer. Also, the Purkinje cell layer and the granule cell layer were missing. Pathology examination was consistent with dysplastic cerebellar gangliocytoma or LDD.

Immunohistochemical analysis was carried out with staining for PTEN and phospho-akt. Figure 5A shows relative paucity of staining in the lesion for PTEN, however there is positive staining seen in

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**Operational diagnosis for individuals**

1) Mucocutaneous lesions alone if
   a) ≥ 6 facial papules with ≥ 3 trichilemmomas,
   b) Cutaneous facial papules and oral mucosal papillomatosis
   c) Oral mucosal papillomatosis and acral keratoses
   d) 6 or more palmar/plantar keratoses or
   2) 2 major criteria, one of which is macrocephaly or Lhermitte-Duclos disease or
   3) 1 major and 3 minor criteria or
   4) 4 minor criteria

**Histologic features**

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Immunohistochemical analysis was carried out with staining for PTEN and phospho-akt. Figure 5A shows relative paucity of staining in the lesion for PTEN, however there is positive staining seen in
Figure 1A& B: Axial T1-weighted MR image of the brain after gadolinium, before (Figure 1A) and after (Figure 1B) resection showing a nonenhancing, relatively hypointense mass in the right cerebellar hemisphere of a patient with Lhermitte-Duclos disease. Compression of the fourth ventricle with resulting ventriculomegaly was present pre-operatively.

Figure 2A& B: Axial T2-weighted MR image of the brain before (Figure 2A) and after (Figure 2B) resection shows a well demarcated mass in the right cerebellar hemisphere, with the characteristic striated appearance, seen in the same patient with Lhermitte-Duclos disease. Compression of the fourth ventricle with resulting ventriculomegaly was present.

Figure 3A& B: Sagittal T1-weighted MR image scan of the brain before (Figure 3A) and after (Figure 3B) resection shows substantial tonsillar herniation down to C2, with subsequent improvement following surgery.

Figure 4: Histologic section under low power (40x) shows microscopic image of the cerebellar cortex. Abnormal neurons found just under the pial surface, essentially replace the normal molecular layer. Also, the Purkinje cell layer and the granule cell layer are missing.
Table 2: Characteristics of 37<sup>a</sup> patients with both Cowden disease and Lhermitte-Duclos disease<sup>b</sup>

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. patients (%)</th>
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<tr>
<td>Age, median (range), years</td>
<td>36 (14-56)</td>
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<tr>
<td>Sex, female : male (n=37)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>31 (84) : 6 (16)</td>
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<tr>
<td>Order of diagnoses</td>
<td></td>
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<tr>
<td>CD, LDD</td>
<td>5 (17)</td>
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<tr>
<td>LDD, CD</td>
<td>24 (83)</td>
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<tr>
<td>(n=29)&lt;sup&gt;+&lt;/sup&gt;</td>
<td></td>
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<tr>
<td>Family history of CD</td>
<td></td>
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<tr>
<td>Present</td>
<td>16 (52)</td>
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<tr>
<td>Absent</td>
<td>15 (48)</td>
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<tr>
<td>(n=31)&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>Recurrence</td>
<td>6 (18)</td>
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<tr>
<td>(n=34)&lt;sup&gt;+&lt;/sup&gt;</td>
<td></td>
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<tr>
<td>Chromosomal analysis performed</td>
<td>6 (16)</td>
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<tr>
<td>(n=37)&lt;sup&gt;c&lt;/sup&gt;</td>
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<sup>a</sup> This number includes our patient

<sup>b</sup> Values are number (percentage) unless otherwise indicated.

<sup>c</sup> n values represent total number of patients for whom information was available.

endothelial cells (serves as an internal control). In Figure 5B phospho-akt shows strong nuclear and cytoplasmic positivity in the abnormal neurons. Immunohistochemical staining was performed as previously described.<sup>13</sup> Following de-paraffinization, antigen retrieval in 10 mM sodium citrate pH 6.0 was performed. Primary antibodies to p-AKT (1-200, Cell Signaling Technologies) and PTEN (1-1000, Cascade Biologics) were applied and incubated overnight at 4°C. Signal was detected using the Envision system (Dako) followed by diaminobenzidine.

Given her diagnosis and family history, the patient and her sister have been referred to the department of cancer prevention for further work-up.

**DISCUSSION**

Cowden disease can be diagnosed on the basis of pathognomonic skin lesions as listed in Table 1.<sup>32</sup> A significant number of patients with CD develop systemic malignancies, 50% to 80% of patients exhibit macrocephaly, and approximately 10% have cognitive impairment.<sup>33</sup> Most patients with LDD present with symptoms of raised intracranial pressure and ataxia. The other manifestations of LDD are macrocephaly, intellectual impairment, and seizures.<sup>34</sup>

Lhermitte-Duclos disease and CD are both heredofamilial diseases. In a review of 34 cases of LDD, Ambler et al<sup>35</sup> described the first familial association of the tumor in both mother and son. The mother died of metastatic breast carcinoma; by current diagnostic criteria she would be considered to have CD. The son had seizures, and both patients had macrocephaly and mental retardation, consistent with CD. The familial occurrence of CD is well-described by Starink et al,<sup>33</sup> and more recently Eng et al<sup>13</sup> described a three-generation family with clinical features of both LDD and CD.

Cowden disease is an autosomal dominant disorder, with a high penetrance in both sexes; it may also occur spontaneously.<sup>33</sup> In 1996, the CD locus was mapped to human chromosome 10q22-23, which is also the locus for the tumor suppressor gene PTEN (the phosphatase and tensin homologue deleted on chromosome 10; also called MMAC1).<sup>5</sup> Most of the tumor-suppressive properties of PTEN are dependent on its lipid phosphatase activity, which inhibits the phosphatidylinositol-3'-kinase (PI3K) Akt signaling pathway through dephosphorylation of phosphatidylinositol-[10,11,35]-triphosphate.<sup>36</sup>

Cowden disease is inherited as a germline mutation and patients who inherit CD in this fashion have a defective PTEN tumor suppressor gene that is present on one allele in every cell in the body.<sup>15,20,37</sup> The occurrence of LDD is predicted to occur
after an additional somatic hit on either the remaining normal CD allele or another unknown gene.\textsuperscript{5,15,37,38} Cowden disease is currently diagnosed on the basis of clinical features alone, and the chromosomal analysis for the defective PTEN tumor suppressor gene contributes to the diagnosis. In our review of the literature six (16\%) of 36 patients tested positive for the defective PTEN tumor suppressor gene, and more than half of the cases had a family history of both LDD and/or CD (Table 2). These symptomatic family members should be closely monitored, because of the increased risk of developing systemic malignancies.

Immunohistochemical analysis in our patient showed a diminished staining for PTEN; however, there was a strong nuclear and cytoplasmic positivity in the abnormal neurons when stained with phospho-Akt (Figure 5). This indicates a defective function of PTEN and confirms the negative regulatory function of PTEN on the PI3/Akt pathway seen in our patient.

The incidence of CD in patients with LDD is still unclear. In a review of the literature, Vinchon et al\textsuperscript{26} found 72 cases of LDD. Twenty-six of these patients had signs and symptoms suggesting CD, and seven had confirmed CD, thus 7/33 cases (21\%) of LDD had CD. Lhermitte-Duclos disease may occur either as sporadic, isolated disease or in association with CD.\textsuperscript{26} Murata et al\textsuperscript{18} concluded in a review article on LDD that approximately 60\% of cases of LDD occur sporadically without association with CD.

Lhermitte-Duclos disease and CD appear to occur with different prevalences in the two sexes. The incidence of CD alone is higher in females than in males.\textsuperscript{33} The incidence of LDD and CD in our review was significantly higher in females (84\%) than in males (6\%) (Table 2). Interestingly, Ambler et al\textsuperscript{35} noted that LDD alone was more prevalent in males and this was further confirmed by Vichon et al.\textsuperscript{26}

In the review by Ambler et al,\textsuperscript{35} the mean age at the diagnosis of LDD alone was 34 years, and the patients showed symptoms of raised intracranial pressure and ataxia. The age of onset of signs and symptoms of patients with LDD in our review was 36 years; the most common symptoms, in decreasing order of incidence, were headaches (58\%), ataxia (45\%), and macrocephaly (45\%) (Table 3). Obstructive hydrocephalus accompanying the cerebellar mass was seen in 53\% of the patients, and over 90\% of the patients with hydrocephalus presented with headaches. The other symptoms included diplopia (13\%), dizziness (9\%), vertigo (6\%), tinnitus (3\%), facial sensory disturbances (3\%), dysarthria (3\%), paraplegia of 7th nerve (3\%) and hypacusis (3\%).

Starink et al\textsuperscript{33} reported that mucocutaneous lesions were the most constant and characteristic finding (100\% incidence), usually in the second decade of life in 21 patients with CD. Macrocephaly was the most common extracutaneous manifestation (80\% incidence). In our review, mucocutaneous trichilemmomas and mucosal papules were the most common dermatologic manifestations. An absence of these dermatologic lesions, however, does not preclude the diagnosis of CD for patients with LDD.\textsuperscript{26} Macrocephaly, like LDD is a major criterion for the clinical diagnosis of CD (see Table 1) and was seen in 45\% of the patients reviewed. Most of the patients (86\%) had skin and mucosal lesions; other lesions, in decreasing order of incidence, were lesions of the breast (62\%), thyroid (57\%), gastrointestinal tract (22\%), uterus (19\%), and ovary (16\%) (see Table 3).

Although LDD was originally described as a pathologic entity, Eng et al\textsuperscript{13} reported a case of a mother and daughter with a family history of both LDD and CD. Neither of these patients had a cerebellar mass, however their signs and symptoms included megalencephaly, macrocephaly, mental retardation, seizure disorder, and ataxia. Eng et al\textsuperscript{13} argue that both the patients had

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<th>Table 3: Radiologic and clinical features in 37(^{a}) patients with both Lhermitte-Duclos disease and Cowden disease</th>
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<tbody>
<tr>
<td>Feature</td>
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<tr>
<td>Radiologic finding (n=30)(^{b})</td>
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<tr>
<td>Left cerebellar mass</td>
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<td>Right cerebellar mass</td>
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<td>Cerebellar mass with hydrocephalus</td>
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<td>Hemispheric mass with vermicular involvement</td>
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<td>Cerebellar mass with Chiari malformation</td>
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<td>Other tumors</td>
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<td>Meningioma</td>
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<tr>
<td>Astrocytoma</td>
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<td>Symptoms at presentation (n=31)(^{b,c})</td>
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<tr>
<td>Headaches</td>
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<tr>
<td>Ataxia</td>
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<td>Macroadenial</td>
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<td>Seizures</td>
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<td>Mental retardation</td>
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<tr>
<td>Diplopia(^{b})</td>
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<td>Organs involved (n=37)(^{b,d})</td>
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<tr>
<td>Skin and mucosal lesions</td>
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<tr>
<td>Breast</td>
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<td>Thyroid</td>
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<td>Gastrointestinal tract</td>
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<td>Uterus</td>
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<td>Malignancies (n=37)</td>
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<td>Breast</td>
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<td>Kidney</td>
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<td>Liposarcoma</td>
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\(^{a}\) This number includes our patient

\(^{b}\) n values represent total number of patients for whom information was available.

\(^{c}\) Other symptoms at presentation were dizziness, 3 (9\%); vertigo, 2 (6\%); tinnitus, 1 (3\%); sudden loss of consciousness, 1 (3\%); enlarging scalp mass (meningioma), 1 (3\%); paraplegia of the 7th nerve, 1 (3\%); syncope, 1 (3\%); left hemiparesis, 1 (3\%); hypoacusis, 1 (3\%).

\(^{d}\) Other organs involved were the lung, 1 (2\%); intra-abdominal, 1 (2\%); cystic hygroma, 1 (2\%); eye, 1 (2\%); kidney, 1 (2\%).
LDD by clinical criteria alone, although the classic pathognomonic anatomic sign of cerebellar hypertrophy was absent. They also postulated that patients with CD who present with clinical symptoms suggestive of LDD should be monitored because the anatomic substrate of LDD (i.e., a cerebellar mass) may occur at a later date. Thomas and Lewis\textsuperscript{24} also described a similar patient without a cerebellar mass to Eng et al.\textsuperscript{13} The exact cause of the neurologic signs and symptoms in these patients is unclear.

The benign systemic manifestations of CD usually involve the skin, breast, and thyroid. The skin lesions seen in our patient were granuloma annulare and sclerotic fibroma. The association between sclerotic fibromas and CD was first reported by Weary et al\textsuperscript{20} in 1972 and sporadic reports of sclerotic fibromas have since been published. Our report is the second case in which the patient had a sclerotic fibroma with a diagnosis of both LDD and CD.\textsuperscript{39} About 50% of patients with CD present with fibrocystic disease of the breast, and 60-70% of patients present with a thyroid goiter and/or adenoma.\textsuperscript{33} Our review indicated a slightly higher incidence of breast involvement (62%) compared with thyroid involvement (57%) in patients with CD. Follicular adenoma is the most common thyroid disorder seen in patients with CD. Hashimoto’s thyroiditis (seen in our case) is rarely associated with CD; previous reports\textsuperscript{33} indicate an incidence of 3-4% in patients with CD.

Our patient had intraductal carcinoma of the breast, which is commonly seen in patients with CD. Most patients are relatively young at presentation and are frequently diagnosed at less than 35 years of age. In an earlier review by Starink et al\textsuperscript{37} of patients with CD, the incidence of breast carcinoma was 22%; in a separate, more recent study, approximately 30-50% of women with CD developed carcinoma of the breast.\textsuperscript{40} Breast carcinoma was bilateral in one-third of these women\textsuperscript{40} and, thus, some authors propose prophylactic subcutaneous mastectomies, especially in cases in which a carcinoma has been diagnosed in one breast. The patient in our report had been diagnosed with breast cancer at 35 years of age and had been treated with bilateral mastectomies. In our review of cases of both LDD and CD, the incidence of breast cancer was 24% (see Table 3).

Information about the timing of the diagnosis of CD was available for 29 patients with both LDD and CD in our review. In 24 patients (83%) CD was diagnosed after LDD was diagnosed. In five patients (17%) CD was diagnosed before LDD was diagnosed. Our review of the literature indicated that approximately 20% of the patients with LDD may also have CD and, hence, neurosurgeons should work up patients with LDD for a possible diagnosis of CD. We believe a diagnosis of either one of these two disorders should prompt a more comprehensive search for the other, because of the increased risk of systemic malignancies. Patients diagnosed with LDD and CD and their families should be kept under close observation and should undergo regular physical examinations and mammography.

Although LDD is described as a benign hamartomatous lesion involving the cerebellum, six of 34 patients (18%) had a recurrence after the initial surgery.\textsuperscript{2,8,12,23,29} Although the median age for the diagnosis of LDD in our study was 36 years, two patients were nine and 11 years old at diagnosis.\textsuperscript{2,23} Surgery remains the treatment of choice, and the role of radiation therapy in these cases of recurrent tumors is still unclear. Malignant transformation of LDD tumors has not yet been described.

Magnetic resonance imaging is the gold standard modality for the diagnosis of LDD.\textsuperscript{41} Typically, as the pathognomonic radiographic feature in LDD,\textsuperscript{17,41} the thickened folia of the cerebellum are well-demarcated and appear striated on magnetic resonance imaging. This finding was also noted in our case (Figure 2B). Magnetic resonance imaging is also sensitive in identifying Chiari malformations in the posterior fossa and syringomyelia.\textsuperscript{42-45} Although secondary tonsillar herniation in patients with LDD has been well-described, their incidence is unknown.\textsuperscript{46} In our patient, the tonsillar herniation reached to the top of C2; this degree of a tonsillar descent in patients with both LDD and CD has not previously been described. In this review we identified three patients (10%) with tonsillar herniation, including ours,\textsuperscript{28,47} all of whom presented with headaches. A patient, reported by Lindboe et al\textsuperscript{16} who presented with headaches had an enlarging scalp mass secondary to a convexity meningioma. Headache is the most common presenting symptom of LDD reported to occur in 58% of patients.

Our patient was treated with a posterior fossa craniectomy and tumor resection. The foramen magnum and upper brainstem were then decompressed by performing C1 and C2 laminectomy, as well as a C1 and C2 duraplasty. This relieved the cervicomedullary compression, and the patient’s symptoms improved substantially. Some authors believe that removal of a posterior fossa mass allows the cerebellar tonsils to ascend. However, we performed a C1 and C2 laminectomy and then the duraplasty because our patient’s symptoms were secondary to the Chiari malformation and because the cerebellar tonsils had severely descended. Tuli et al\textsuperscript{44} performed a craniectomy, as well as a C1 laminectomy, followed by a decompressive duraplasty, in all patients with LDD to optimally improve symptoms and because the lesion cannot be totally resected as a result of poorly defined margins.

Meningiomas have been reported in several patients with CD, with a prevalence of approximately 3%.\textsuperscript{2,16,22} In our review of patients with LDD and CD, the incidence of intracranial meningiomas was 7%. Lyons et al\textsuperscript{48} concluded that patients with CD have a 1000-fold increased risk of developing meningiomas. An increased incidence of meningiomas is characteristic of neurofibromatosis 2, for which the genetic defect has been traced to a locus on the long arm of chromosome 22. The \textit{PTEN} gene (a tumor suppressor gene similar to neurofibromatosis 2) responsible for CD, however, has not been shown to play a substantial role in the pathogenesis of sporadic meningiomas.\textsuperscript{49} Two cases of astrocytoma and LDD have been previously described.\textsuperscript{50,51} In this report, we identified an additional patient who underwent a partial resection of a third ventricular tumor, which was identified as a pilocytic astrocytoma.\textsuperscript{56} This is the only report of a patient with an astrocytoma and a diagnosis of both LDD and CD. There is no evidence to suggest that the incidence of astrocytic brain tumors is higher in patients with LDD and CD than in the general population. Nevertheless, regular brain radiographic follow up examinations should be performed in all patients with both LDD and CD to identify an LDD recurrence or the development of a \textit{de novo} brain tumor, especially a meningioma.

As more than 80% of the patients in this review were diagnosed with CD after they were diagnosed with LDD, we believe that CD remains under-diagnosed and possibly under-reported. Patients with LDD should be closely examined for the...
muco-cutaneous signs of CD, which usually antedate the diagnosis of
LDD. Once a diagnosis of CD is established, close surveillance is
 imperative because these patients have an increased risk of
developing systemic malignancies. The patients should also be
monitored for LDD recurrence and the possibility of de novo
brain tumors. New-onset headaches in a patient with CD should
be thoroughly investigated because of the possibility of LDD,
other brain tumors, or tonsillar herniation. It is imperative that the
neurosurgeons be aware of the clinical stigmata of CD in cases in
which the patient presents initially with a posterior fossa mass and
LDD. Surgical intervention in patients with LDD and secondary
Chiari malformation should include suboccipital craniectomy,
foramen magnum decompression, and cervical laminectomy to the
lowest level of tonsillar herniation, and duraplasty.

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