Abstract
Myeloid sarcoma is a rare neoplasia consisting of immature myeloid cells localized at an extramedullary site. We report a case of a 55-year-old woman with a past medical history of myasthenia gravis (MG) disease treated with thymectomy 17 years earlier who presented with a painful lesion in her right acetabulum. Findings from pathology and imaging are consistent with the diagnosis of a myeloid sarcoma. The patient was treated with chemotherapy with an Acute Myeloid Leukemia protocol. At 1-year following initial presentation, PET scans reveal no further evidence of disease. Further follow up and surveillance is needed to determine if the patient will remain free of disease and recurrence.

Myeloid sarcoma is an extramedullary mass of immature myeloid cells that can be associated with acute and chronic myeloid leukemia.1-3 Review of the literature reveals that some patients developed chronic myeloid leukemia after undergoing a thymectomy and receiving immunosuppressants as treatment for myasthenia gravis disease.6 We present a case of a patient who received a thymectomy to treat her myasthenia gravis disease and developed myeloid sarcoma in her right acetabulum 17 years later without ever displaying any evidence of leukemia.

Case Report
A 55-year-old woman with a prior history of myasthenia gravis treated with thymectomy presented with right hip pain made worse with ambulation. The pain awakened the patient from sleep at night. The patient underwent a plain x-ray of her hip and then computed tomography (CT) of her pelvis. CT examination of the pelvis (Fig. 1) along the puboacetabular junction demonstrated subtle intramedullary infiltration in the region of the anterior acetabulum. MRI demonstrated marrow replacement of the right puboacetabular junction with T1 hypointense and T2 hyperintense signal extending for approximately 3 cm (Fig. 2). There was also slight extraosseous extension of the lesion anteriorly (Fig. 2). A whole body bone scan demonstrated increased radiopharmaceutical tracer uptake solely in the puboacetabular junction (Fig. 3). Complete blood count (with differential), serum protein electrophoresis and a C-reactive protein showed no abnormalities. Complete metabolic panel showed a high glucose level but was otherwise normal.

The patient underwent an open biopsy of the junction of the superior pubic ramus and anterior acetabulum. The obtained material consisted of a 3 cm x 3 cm x 0.3 cm aggregate of tan-red tissue. Microscopic examination showed sheets of immature appearing cells with moderate amount of slightly eosinophilic cytoplasm, variable size nuclei with irregular outlines, finely dispersed chromatin, and inconspicuous nucleoli (Fig. 4). Immunohistochemistry revealed positive staining of the tumor cells for CD43 and myeloperoxidase (negative for CD20, CD79a, CD30, CD99, CD3, CD138, AE1/3 and Cam 5.2). Flow cytometry on bone marrow aspirates revealed no abnormalities. These results were consistent with a diagnosis of myeloid sarcoma. CT scans
of chest, abdomen, pelvis, a bone scan, MRI, and PET scan revealed that the lesion was limited to the right acetabulum and pubis.

The patient was treated with chemotherapy lasting over a 1-year period with an Acute Myeloid Leukemia Protocol and by consolidative radiation therapy to the right acetabulum and pubis. Specifically, the patient received 3600 cGy in 18 fractions through anterior and posterior fields. One year later, PET scans revealed no interval changes relative to previous studies. The patient is presently alive and doing well without evidence of leukemia or recurrence and undergoing surveillance.

**Discussion**

Myeloid sarcoma is a mass of immature myeloid cells that is seen more often in children than adults without gender predominance. Myeloid sarcoma was originally named “chloroma” due to the green color of the tumor, which is generated by the presence of myeloperoxidase. The histomorphological presentation of myeloid sarcoma is very similar to poorly differentiated lymphoma, and thus myeloid sarcoma may be misdiagnosed as lymphoma.

Paydas and coworkers presented 32 cases of myeloid sarcoma and found 13 cases that were associated with acute myeloid leukemia and 11 cases that were associated with chronic myeloid leukemia. Out of the 32 cases, myeloid sarcoma predated the diagnosis of leukemia in eight cases by 0.5 to 24 months and was simultaneously diagnosed with leukemia in five cases. Along with other sources, this suggests that the detection of myeloid sarcoma may occur prior to, concurrently with, or after the diagnosis of acute or chronic myeloid leukemia. Thus, a diagnosis of myeloid sarcoma should be seriously considered when a mass is detected in leukemic patients.

Soft tissue myeloid sarcomas have a nonspecific imaging appearance, typically presenting as multiple masses isodense to muscle on CT and mildly T1 hypointense and T2 hyperintense on MRI. As this appearance can easily mimic other soft tissue neoplasms, such as lymphoma or other primary sarcomas, a history of underlying hematologic malignancy is essential to diagnosis. Peripheral enhancement with central hypodensity has been described on CT as may be seen with...
an abscess. Ultimately, multiple, enhancing solid masses occurring at different points in time and in different locations throughout the body in a patient with underlying hematologic disorder or malignancy should suggest the diagnosis.\textsuperscript{10-12}

Myeloid sarcoma is commonly localized in lymph nodes, soft tissues, bone, and solid organs.\textsuperscript{1-3,7,11} In pediatric populations, it mostly involves the subcutaneous tissues and orbits. One study on bone tumors suggests that 10% of myeloid sarcoma involve the skeleton and mostly involve the long tubular bones.\textsuperscript{2} However, autopsies performed on leukemia sufferers in the aftermath of the Hiroshima and Nagasaki bombings have suggested osseous involvement of myeloid sarcoma in up to almost 92% of patients.\textsuperscript{11-13}

Out of the 32 cases presented by Paydas and coworkers,\textsuperscript{9} there were four cases (12.5%) of myeloid sarcoma involving the bone in which osteolytic lesions were detected in the femur, humerus, pelvis, and cervical vertebra. The patient with femur-localized myeloid sarcoma did not have any signs or symptoms of hematological disease and was treated with radiotherapy. Humerus-localized myeloid sarcoma was detected in the patient 23 months after the diagnosis of chronic myeloid leukemia. The patient was treated by tumor excision and later arm amputation. Pelvic bone myeloid sarcoma was found in a patient 12 months after diagnosis of chronic myeloid leukemia. This patient was treated with tumor excision and later arm amputation. Pelvic bone myeloid sarcoma was found in a patient 12 months after diagnosis of chronic myeloid leukemia. This patient was treated with radiation therapy and imatinib. In the last case, the patient was diagnosed with acute myeloid leukemia that went into remission after chemotherapy, but myeloid sarcoma was later detected in the cervical vertebra, which was treated by radiation therapy. The three patients who had myeloid sarcoma involving the bone as well as leukemia survived for less than 2 years after the initial finding of myeloid sarcoma. There was no follow up on the patient who developed femur-localized myeloid sarcoma without hematological disease.\textsuperscript{9}

A retrospective study on the prognosis of 24 leukemic myeloid sarcoma cases found that the median survival from the discovery of myeloid sarcoma was 9 months, and the 5-year survival rate was 21% suggesting that prognosis of leukemic myeloid sarcoma is poor.\textsuperscript{7} Whether the myeloid sarcoma antedates leukemia, the gender or age of the patient and the localization of myeloid sarcoma did not have prognostic significance.\textsuperscript{7} Patients with both chronic myeloid leukemia (or a myeloproliferative disorder) and myeloid sarcoma have worse prognoses relative to those with only chronic myeloid leukemia (or myeloproliferative disease) because myeloid sarcoma discovery often antedates acute or blast transformation.\textsuperscript{3,10} There are no prognostic differences between acute myeloid leukemia patients with myeloid sarcoma and those with only acute myeloid leukemia.\textsuperscript{3,4} Lastly, Neiman and colleagues suggest that nonleukemic myeloid sarcoma patients who remain untreated are at risk for developing acute leukemia.\textsuperscript{10}

Review of medical literature suggests that chemotherapy is a moderately effective treatment option for myeloid sarcoma. Lan and associates\textsuperscript{7} reported that leukemic myeloid sarcoma patients who received chemotherapy had significantly higher median survival rates relative to those who did not receive chemotherapy. Although the myeloid sarcoma tumor responds to focal irradiation, Lan and associates found that surgery and radiation did not significantly enhance survival in leukemic myeloid sarcoma cases.\textsuperscript{7} Tsimberidou and coworkers report that anti-leukemic chemotherapy may be effective for treating nonleukemic myeloid sarcoma as well.\textsuperscript{14} Overall, myeloid sarcoma tumors tend to resolve in less than 3 months but recur in 23% of patients.\textsuperscript{3}
Myasthenia gravis (MG) is a rare neuromuscular autoimmune disease that is sometimes accompanied with thymoma.\textsuperscript{6,15} The prognosis can be more severe if acetylcholine receptor antibodies are found in the patient with myasthenia gravis.\textsuperscript{15} The disease can be treated with immunosuppressants and thymectomy.\textsuperscript{6,15}

Review of the literature suggests that patients (especially young patients) who received a thymectomy may become immunodeficient. Brearley and coworkers reviewed 18 pediatric patients (ages range from 1 day to 3 months) who received a thymectomy\textsuperscript{16} and found that thymectomized children had lower levels of both CD4+ and CD8+ T cells relative to appropriate controls.\textsuperscript{16} A study on the long-term effects of thymectomy on 16 MG patients (whose age ranged from 24 to 71 years) reports that MG patients who had been thymectomized for at least 8 years displayed T cell lymphopenia relative to normal controls.\textsuperscript{17} Another study found that thymectomized MG patients displayed lower cytotoxic CD8+ T cell activity.\textsuperscript{18}

Since cytotoxic T lymphocytes play an important role in the destruction of tumor and cancer cells, thymectomized myasthenia gravis patients may be more susceptible to cancer development. Ranakkel and colleagues presents a myasthenia gravis (without thymoma) patient who developed chronic myeloid leukemia 68 months after receiving a thymectomy and steroids.\textsuperscript{6} Aguiar and associates and Wangers and coworkers each reported a patient with myasthenia gravis (with thymoma) who developed chronic myeloid leukemia after receiving a thymectomy and immunosuppressive therapy.\textsuperscript{6}

Our patient previously received a thymectomy as treatment for her myasthenia gravis disease and developed myeloid sarcoma in her right acetabulum 17 years later without ever displaying any signs of leukemia. The development of myeloid sarcoma in her right acetabulum was highly suggestive of being the initial manifestation of leukemia. Thus, in accordance with the current literature, this case further supports the concept that thymectomies, as treatments for autoimmune disorders such as myasthenia gravis, may increase the susceptibility to cancers such as leukemia. Treatment by radiation therapy and chemotherapy with acute myeloid leukemia protocol are based on our current understanding of the natural history and progression of this disease. One year later, PET scans revealed no evidence of disease. Further follow up and surveillance is needed to determine if the patient will remain free of leukemia and recurrence.

**Disclosure Statement**

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

**References**