Evidence for a primary malignant bone tumor in a pre-Columbian skeleton from Cerro Brujo, Bocas del Toro, Panamá

Nicole E. Smith-Guzmán, Smithsonian Tropical Research Institute

Introduction

The site of Cerro Brujo (CA-3), located in Almirante Bay, Aguacate Peninsula, Bocas del Toro in Western Panama (see map, Fig. 1) and consisting of a series of shell middens dating to between 900-1100 CE, was excavated by Olga Linares and Tony Ranere in 1969 as part of a broader research project on the ecology and prehistory of Western Panama (Linares de Sapir 1971).

Figure 1. Map of Panama showing the location of Cerro Brujo.

One of only two burials encountered at the site, burial CA3 6H consists of the incomplete skeleton of a young adult female who lived only to her middle to late teens (Fig. 2). Upon gross examination in 2016, it was observed that the right humerus of this individual contains a highly mineralized osteoblastic lesion consistent with an aggressive neoplasm originating within the diaphysis of the bone. Many of the other skeletal elements available for study presented pathological lesions indicating anemia and systemic inflammation, likely stemming from the effects of the neoplasm on the body. In this study I describe in detail the macro- and microscopic appearance of the neoplasm, its radiological morphology, and through differential diagnosis consider its likely diagnosis.

Figure 2. Excavation photo of burial CA3 6H *in situ*. From Linares de Sapir (1971).

Methods

Burial CA3 6H was estimated to be of 13-17 years of age through dental and skeletal development (lack of third molars but fully developed long bones; Ubelaker 1989). The sex was determined to be female through cranial indicators (Acsádi and Nemeskéri 1970) alone due to the complete absence of the os coxae. The skeleton was observed macroscopically for pathological lesions, revealing the presence of cribra orbitalia, severe porotic hyperostosis (Fig. 3), active periosteal reactions in both tibiae, and a lesion consistent with primary bone neoplasm affecting the right humerus at roughly midshaft (Figs. 4-5).

The humeral lesion lacked the typical unorganized woven bone characteristic of a fracture callus. The combination of lytic lesions associated with an osteoblastic mass, coupled with the appearance of dense, mineralized tissue originating from within the diaphysis of the bone and expanding outwards at a perpendicular angle is consistent with the appearance of a primary malignant bone neoplasm (Ortner 2003). The age of the individual and apparent sequelae of systemic anemia and inflammation present in other skeletal elements agree with characteristics seen in clinical cases of these types of cancer.

Radiographs were taken of the humerus to assist in differential diagnosis of the lesion. Differential diagnosis considered descriptions of primary bone neoplasms in both modern clinical and paleopathological literature.

Results & Differential Diagnosis

Primary malignant bone tumors, or sarcomas, are classified into three main types: osteosarcoma, chondrosarcoma, and Ewing's sarcoma (Ortner 2003). All three of the sarcomas are common during development when there is active, accelerated growth along the growth plates, or metaphyses, of the long bones. Differentiation between these three sarcoma types in clinical settings is generally based on the age of the patient, appearance of the tumor, and affected area of the body.

Osteosarcoma

Osteosarcoma, the most common type of primary bone tumor, occurs in adolescents and young adults, affecting males more often than females. It affects the distal femur, proximal tibia, and proximal humerus most often, but can affect other long bones and rarely the skull. This tumor can cause a lytic, sclerotic, or mixed reaction of the bone it affects, taking on a characteristic "sunburst" appearance of spiculated bone extending perpendicular to the cortex, a "cauliflower" appearance of lobulated sclerotic bone, or a "moth-eaten" appearance of permeated bone.

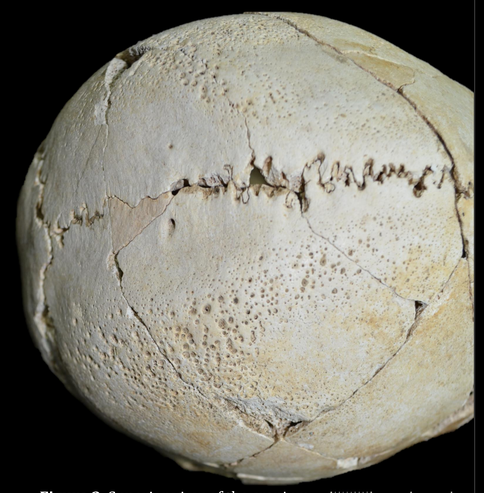

Figure 3. Superior view of the cranium of burial CA3 6H showing severe, expansive porotic hyperostosis.

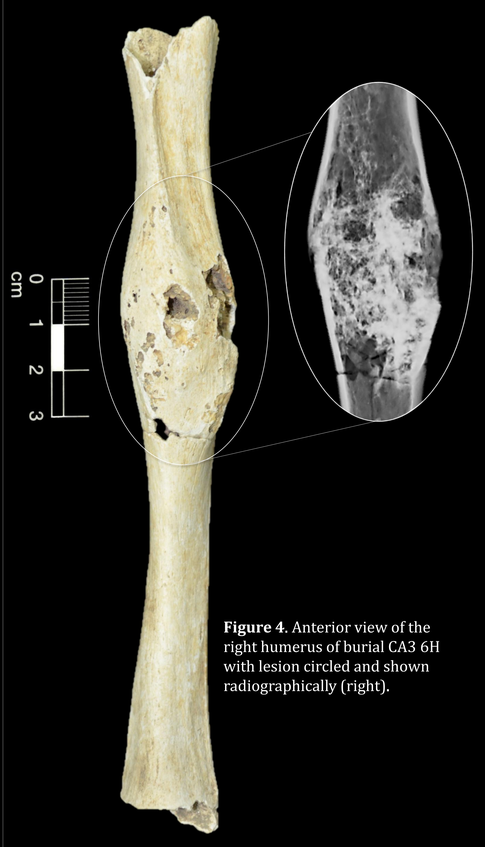

Figure 4. Anterior view of the right humerus of burial CA3 6H with lesion circled and shown radiographically (right).

Chondrosarcoma

Chondrosarcomas occur in adolescents through individuals of adult age, and affect males and females equally. It frequently affects the proximal and distal femur, proximal humerus, and pelvis, and occurs uncommonly in other skeletal elements. In its mature forms, the tumor becomes mineralized, appearing more organized and having a more nodular characteristic shape than osteosarcomas and causing endosteal scalloping of the cortex.

Ewing's sarcoma

Ewing's sarcoma, the third most common primary bone tumor in modern populations, is seen commonly in childhood and adolescence but rarely in adults. This tumor, unlike the other two sarcomas, does not produce matrix, and, therefore, is able to permeate through intertrabecular and intracortical spaces. Its appearance is generally lytic, involving a large segment of the diaphysis of the long bone or the pelvis and presenting an "onion skin" layered periosteal reaction with haversian canal invasion.

Gross and radiographic features of the CA3 6H humerus

The lesion present on the right humerus of burial CA3 6H contains highly mineralized bone associated with an enlarged diaphysis and localized lytic lesions near the midshaft of the bone. Radiographically, the lesion appears moth-eaten, with spicules of radiolucent dense bone oriented perpendicular to the long axis of the bone shaft, particularly in relation to the anterior aspect of the bone as visible in the medial view (Fig. 5). Upon comparison with other known cases of neoplasms on dry bone, the lesion aligns most with the appearance of an osteosarcoma; however, its location on the diaphysis of the bone is uncommon for this type of tumor. Nevertheless, Ewing's sarcoma, which does commonly affect this location, would be expected to have more lytic features visible radiographically. Furthermore, the severe lesions of anemia and inflammation visible in other areas of the skeleton suggest the tumor affected the health of this individual for some time, allowing for its potential shift away from the metaphysis with normal bone growth.

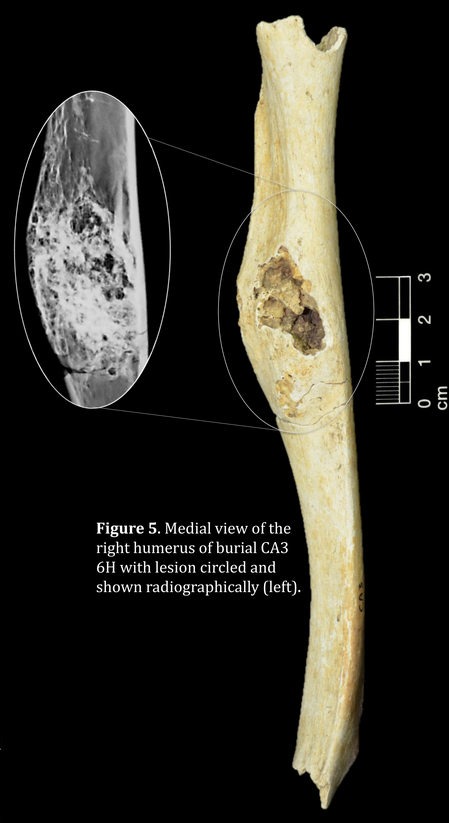

Figure 5. Medial view of the right humerus of burial CA3 6H with lesion circled and shown radiographically (left).

Discussion

Based on the gross and radiographic appearance of the lesion on the right humerus of burial CA3 6H, a retrospective diagnosis of malignant bone sarcoma was made, including osteosarcoma, chondrosarcoma, and Ewing's sarcoma. Following modern clinical characteristics of these types of tumors, the most likely diagnosis is osteosarcoma; however, there are some discrepancies that lead to uncertainty in the diagnosis.

The archaeological evidence showed that the population inhabiting the small hamlets of Cerro Brujo included in their diet meat from primarily marine resources (76%), but plant and terrestrial resources as well (Linares and Ranere 1980). Based on radiocarbon dating and pottery chronology, the population inhabited the Aguacate peninsula between 900-1100 CE. Burial CA3 6H was associated with clay pellets (perhaps used as rattles), and a shell trumpet.

Primary cancers of bone are rare in modern clinical settings, and even rarer to find in archaeological contexts. Only a handful of potential diagnoses of sarcomas have appeared in paleopathological literature, appearing in areas of the world where the most skeletons have been analyzed (Egypt, Europe, and Andean South America). This study comprises the first case of probable cancer reported from a pre-Columbian site in Central America, where there is a relative paucity of human skeletal analyses by trained specialists in physical anthropology and paleopathology.

Although several cancers have shown evidence of infectious causes, primary bone cancers affecting children and adolescents are thought to be associated with rapid growth along the metaphyses of the bone. In the case of burial CA3 6H, this rapid growth could explain the presence of the tumor, having begun to develop during early growth and migrated to the midshaft of the bone as the bone grew.

Future diagnostic probes seeking a more narrow diagnosis of the type of sarcoma affecting burial CA3 6H will include consultation with pediatric primary bone neoplasm specialists and potential histological and scanning electron microscope assays. Furthermore, a tooth from this individual will be sent to Mélida Nuñez for assessment of ancient DNA.

Literature cited

Acsádi G, Nemeskéri J. 1970. *History of Human Life Span and Mortality*. Akadémiai Kiadó: Budapest.

Linares de Sapir O. 1971. Cerro Brujo: A tiny Guaymí hamlet of the past. *Expedition Magazine* 13(2):27-35.

Linares OF, Ranere AJ. 1980. Adaptive Radiations in Prehistoric Panama. Harvard University Press: Cambridge, MA.

Ortner DJ. 2003. *Identification of Pathological Conditions in Human Skeletal Remains*. 2nd ed. Academic Press: San Diego.

Ubelaker DH. 1989. *Human Skeletal Remains*. 2nd ed. Taraxacum Press: Washington, D.C.

Acknowledgments

I thank Richard Cooke for providing me with the temporary contract position during which time the humeral lesion was discovered, and Centro Radiológico Metropolitano for assistance and expertise imaging the lesion. Cerro Brujo was excavated with support from the National Science Foundation (NSF-GR-2846) awarded to Olga Linares.

For further information

Please contact *nicolesmithguzman@gmail.com*. More information on this and related projects can be obtained at *https://stri.academia.edu/NicoleSmithGuzmán*.

Smithsonian Tropical Research Institute