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Research article

No stone unturned: The presence of kidney stones in a skeleton from 19th century Peoria, Illinois

Thomas C. Jaskowiec[a,*], Anne L. Grauer[a], Michael Lee[a], Sean Rajnic[b]

[a] Loyola University Chicago, 1032 W. Sheridan Rd, Chicago, IL 60660, United States
[b] University of Illinois Medical School, 1601 Parkview Avenue, Rockford, IL 61107, United States

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ABSTRACT

During the excavation of the 19th century Peoria City Cemetery (Peoria, Illinois), a skeleton of a female, aged 20–30 years old, was found with large, bilateral calcified masses in the abdominal region. The masses were analyzed by Fourier transform infrared (FTIR) spectroscopy, and the results compared to published clinical data in an effort to determine the etiology of the stones. The calcified masses were determined to be staghorn struvite uroliths, which commonly result from chronic urinary tract infection and likely impacted the overall health of this individual.

1. Introduction

In 2009, an excavation of the Peoria City Cemetery (ca. 1839–1886) yielded 86 individuals of wide demographic age ranges and economic means (Bird and Grauer, 2012). One individual (BF 219) was recovered with multiple large bilateral irregularly shaped masses (Figs. 1 and 2), located immediately adjacent to the 12th thoracic vertebra and lumbar vertebrae 1 and 2. These were initially identified as staghorn calcified masses, which are visibly recognizable by their antler-shaped morphology.

Calcified masses have occasionally been recovered associated with archaeological or mummified remains (for examples see Anderson, 2003; Giuffra et al., 2008; Komar and Buikstra, 2003; Özdemir et al., 2015; Perry et al., 2008; Streitz et al., 1981) (Table 1). There are, however, few published reports of calcified kidney stones in the archaeological record (Edwards et al., 2010; Morris and Rodgers, 1989; Shattock, 1905). As Özdemir et al. (2015) assert in their assessment of a bladder stone recovered from an 11th century skeleton in Turkey, “mineralogical and elemental compositions of the object are important to define the possible causes” (p. 835) of calcified masses. Hence, the goal of this study was to shed light on the presence of kidney disease in the past by determining the chemical composition of the staghorn masses using Fourier transform infrared (FTIR) spectroscopy, and by comparing the results to clinical data as a means of evaluating their etiology.

FTIR spectroscopy is a technique whereby infrared radiation interacts with a sample and a photon of light is absorbed when the energy of the wavelength of the light matches the energy of a molecular vibration. The infrared spectrum is composed of a number of bands, some overlapping, which show a unique chemical signature of the material being analyzed. The shape, position, and width of the peaks allow comparisons between known chemical signatures to identify the components of the sample. A significant factor in using FTIR spectroscopy for the analysis of calcified masses is the precision and ease of repetition, and only a small amount of required material (Basiri et al., 2012; Carmona et al., 1997; Estepa and Daudon, 1997).

There are three common types of kidney stones: calcium, magnesium ammonium phosphate (struvite), and uric acid stones. Calcium stones are the most common, comprising over 80% of all stones, and most frequently found in men (Basiri et al., 2012; Coe et al., 2005; Finkielstein and Goldfarb, 2006). There are two main variants of these stones: calcium oxalate and calcium apatite. Neither tend to progress to a staghorn state due to inhibitors in the urine (Akagashi et al., 2004). The etiology of calcium oxalate stones is often an imbalanced concentration of oxalate and calcium due, at times, to diet and absorptive abnormalities (Liebman and Al-Wahsh, 2011; Taylor et al., 2004). Calcium apatite stones are formed similarly to calcium oxalate, but the main risk factor is higher urine pH (>6.7) (Coe et al., 2005). Struvite stones, which can develop a staghorn morphology, are caused by the nucleation of magnesium, phosphate, and ammonium (products of urease producing bacteria). Hence, they are often associated with urinary tract infections, and most commonly found in women (Jennis et al., 1970; Griffith, 1978). Staghorn morphology occurs as they grow to occupy the major calyces of the kidney. These calculi are too large to naturally pass, and therefore clinically today are often treated aggressively through surgery. Left untreated, the calculi will eventually

* Corresponding author at: Department of Anthropology, University of Missouri, 112 Swallow Hall, Columbia MO 65211, United States.
E-mail address: tjaskowiec@mail.missouri.edu (T.C. Jaskowiec).

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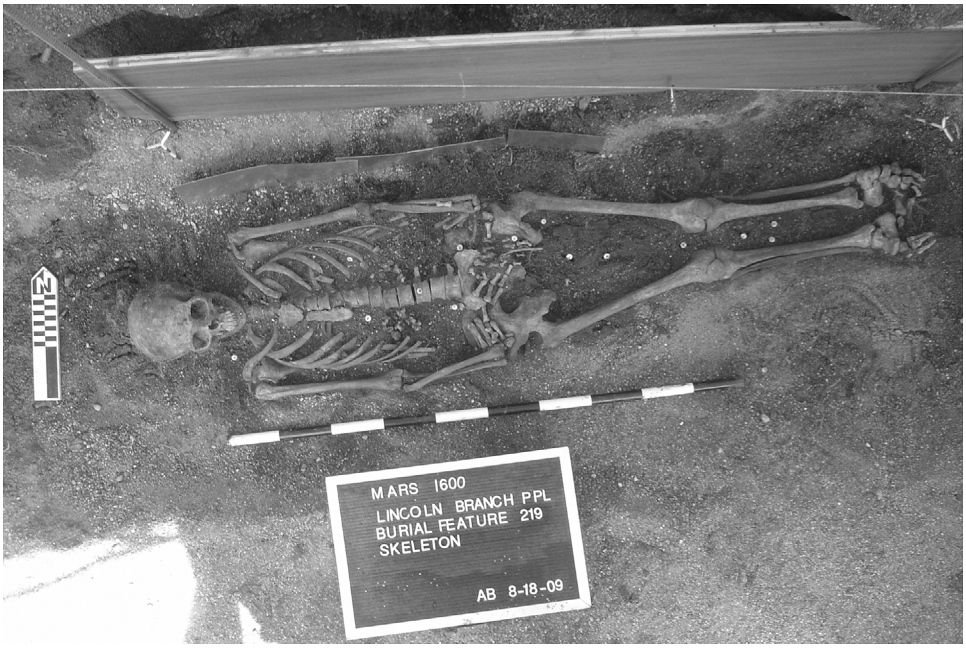

Fig. 1. Individual BF 219 *in situ.*

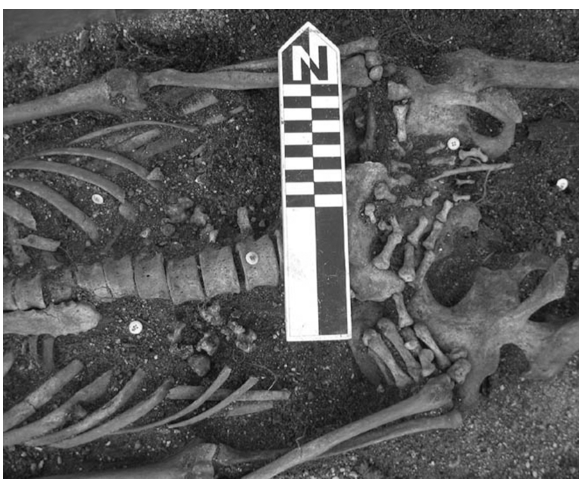

Fig. 2. Multiple large bilateral irregularly-shaped masses located immediately adjacent to the 12th thoracic vertebra and lumbar vertebrae 1 and 2, appear to be staghorn kidney stones (also referred to as uroliths or renal calculi).

destroy the kidney and the individual will likely die (Blandy and Singh, 1976; Gambaro et al., 2001; Rous and Turner, 1977). Cultures of struvite stone fragments show that bacteria reside within the stone itself (Preminger et al., 2005). Finally, uric acid kidney stones are commonly associated with gout (inability to excrete excess uric acid), diets high in animal protein (increased protein load resulting in excess purines), and genetic factors (Moe et al., 2002).

2. Methods and techniques

Age-at-death determination was performed based on observation of morphological changes of the pubic symphysis (Brooks and Suchey, 1990; Hartnett, 2010), the auricular surface of the ilium (Osborne et al., 2004), and fusion of the medial clavicle (Langley-Shirley and Jantz, 2010). Determination of sex of adult skeletons was based on sexual dimorphism of the cranium and *os pubis* (Phenice, 1969; Walker, 2005, 2008; Volk and Ubelaker, 2002).

Fragmented samples from the individual's right side were collected, totaling a combined 45 mg sample. Spectroscopic grade potassium bromide (KBr) was mixed with the sample, crushed with an agate mortar and pestle, and then compressed into separate discs. The Bruker Tensor 37 FTIR spectrometer was purged with nitrogen prior to use. A background scan was collected from a KBr pellet, and then the two sample discs were individually scanned on the same machine at a spectral resolution of 4 cm^{-1}, with the sample scans then averaged together. Data derived from our analysis were then compared to the published clinical data (Benramdane et al., 2008; Channa et al., 2007; Estepa and Daudon, 1997; Silverstein et al., 2005).

3. Results

BF 219 was a young woman approximately 20–30 years old. The auricular surfaces displayed loss of billowing and areas with coarsening

Table 1
Characteristics of Archaeological Uroliths/Calcified Masses.

Published Archaeological Uroliths/Calcified Masses	Region	Type of Remains	Location and Characteristics of Recovered Uroliths
Shattock (1905)	Egypt	Mummified remains	Kidney stone regularly shaped
Morris and Rodgers (1989)	Cape Province, South Africa	Skeletal remains	Kidney stone non-staghorn shaped
Edwards et al. (2010)	East Yorkshire, United Kingdom	Skeletal remains	Kidney stone regularly shaped
Anderson (2003)	Norwich, United Kingdom	Skeletal remains	Bladder stone regularly shaped
Guiffra et al. (2008)	Borgo Cerrato, Italy	Mummified remains	Bladder stone regularly shaped
Komar and Buikstra (2003)	Koster, Illinois, USA	Skeletal remains	Calcified lymph node or calcified ovary regularly shaped
Özdemir et al. (2015)	Amasya, Turkey	Skeletal remains	Bladder stone regularly shaped
Perry et al. (2008)	Aqaba, Jordan	Skeletal remains	Calcified parasite spherical shape with tubular construction
Streitz et al. (1981)	Northeast Arizona, USA	Mummified remains	Bladder stone regularly shaped