H58 Antemortem vs. Perimortem Infant Rib Fracture: The Histological Evidence

Murray K. Marks, PhD, University of Tennessee, 250 South Stadium Hall, Knoxville, TN 37996; Mariateresa A. Tersigni, PhD, Joint POW/MIA Accounting Command Central Identification Laboratory, 310 Worchester Avenue, Building 45, Hickam AFB, HI 96853; and Darinka Mileusnic, MD, PhD, Knox County Medical Examiner's Office, 1924 Alcoa Highway, U-71, Knoxville, TN 37920*

After attending this presentation, attendees will understand healing (or chronic) infant rib fractures compared to acute (or perimortem) and the histological appearance of these fractures. This knowledge will better enable them to specifically identify these lesions in both fresh and dried specimens, i.e., at autopsy or in the field, respectively.

This presentation will impact the forensic community and/or humanity by demonstrating how the diagnosis of antemortem and perimortem rib fractures in infants and children has major significance to the forensic investigation. Being able to sequence these wounds enables the investigator the ability to provide a history of abuse which allows the pathologist discernment of the cause and manner of death and the investigator a time line to possibly place a perpetrator with a victim.

Even though malleable, infant ribs are vulnerable to fracture when the torso is impacted during abuse. Besides numeric, sequencing and mechano-functional interpretation, a temporal understanding of rib fractures is critical to the forensic investigation, especially in diagnosis of antemortem from perimortem breakage. Interpretation is more difficult than seemingly simple visual ascertainment of a fresh fracture versus callus formation. Decipherment of the antemortem insult becomes complex when the woven bone callus disintegrates under a later perimortem stress to reveal a macroscopic fresh break. How are such events interpreted and what effect may this have on the admissibility of evidence on a temporal assignment of antemortem fracture? For instance, a suspect is charged on a specific date with perimortem assault and the anthropologist may or may not be prevented from testimony that demonstrates a history of abuse. What can the anthropologist contribute to the interpretation of "time since trauma" when it comes to rib fractures? Sauer (1998) advanced the initial understanding of these phenomena by explaining precise criteria for diagnosis of these events. Can accuracy be achieved macroscopically or is histology a necessity to diagnose?

Six antemortem and perimortem fractured ribs from two abused infant victims and the distal humerus from one of them were transversely sectioned for light microscopy following the methods of Tersigni (2005). These wounds were inflicted four to eight weeks prior to death. All damaged bone was past the inflammatory and in the reparative phase of healing as defined by Martin *et al,* (1998). From the midline of the fracture callus posterior to the non-traumatized bone cortex, half of each rib was embedded in epoxy resin and sectioned using a Buehler Isomet 1000 with a diamond blade. The sections were glass slide mounted with Permount and reviewed using a Leica DMRX research light microscope at 15x, 50 xs, and 100x magnification. Digital images were taken using a Sony video uplink and captured using Image Pro Express 4.0. The anterior half of the rib was reviewed using SEM using a LEO 1525 Field Emission. This rib portion from the other side was examined to identify the extent of active bone remodeling following the segments anterior to the fracture.

Not surprisingly, under LM and SEM the fracture callus appears as a disorganized, amorphous mass of woven bone similar in many ways to a periosteal inflammatory response or the response involving cartilage. The latticework within the callus is poorly organized and minimally and marginally attached to the underlying periosteal surface of the rib through small bony spicules/projections. The callus structure functions specifically as an immobilizer for the compromised bone so that healing may take place at the fracture site. The resulting osseo-cartilagenous structure is congruent with the typical blastic events characteristic of the ossification processes of the hematoma. However, the quality of bone making up the callus proper

is not the quality of uncompromised bone given the lack of true lamellar and Haversian organization. In the heart of the callus there is evidence of a specific endosteal/ medullary callus forming between the originally severed ends.

In the non-traumatized bone adjacent to the fracture site there is a gradual level of involvement typical of the inflammatory tissue response of the periosteum. However, this may be difficult to decipher. The adjacent periosteal layer demonstrates a gradual thickening from the fracture site to normal thickness further away from the fracture. The cortical bone appearance within the fracture proper and immediately adjacent demonstrates remodeling given a higher rate of blastic activity. The SEM examination of the rib surfaces moving away from the callus reveals a three dimensional cone-shaped zone of healing that gets narrower as the examiner moves toward uncompromised bone along with a decrease in cortical thickness.

Given the time frame of one to two months post-trauma, all wounds examined were beyond the inflammatory phase and the reparative phase is active and near completion. In fact, within one month, Martin *et al*'s (1998) inflammatory response, i.e., the reason for the callus and the reparative phase of callus formation has been achieved and is moving toward the remodeling phase. Here, diminution of the woven bone callus with new bone contoured and molded as the re-instated functional demands are placed on the structure is seen.

Like any newly formed woven bone, the quality of bone in the fracture callus is poor and unsuited to withstand

 ** Presenting Author*

subsequent rigors of compression trauma/loading. Therefore, it is not uncommon, in cases of episodic child abuse, to find seemingly fresh breaks contained within the antemortem callus since no remodeling of the original fractured parts are macroscopically visible until the bone initializes Martin *et al*'s "remodeling phase." If the portions of the callus are lost at autopsy or during skeletal processing, care must be taken not to interpret a perimortem fracture site from an antemortem event

Histology, Child Abuse, Infant Bone Fractures

 ** Presenting Author*