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The Sternal Foramen: The Possible Forensic Misinterpretation of an Anatomic Abnormality

Misinterpretations of autopsy findings have been a major cause of concern to forensic scientists. Two comprehensive catalogues of the more common mistakes in forensic pathology and the interpretation of artifacts encountered in the medicolegal autopsy have been published [1,2]. This article documents the occurrence of a relatively rare congenital anomaly which may be misleading and may result in serious erroneous conclusions, particularly when evaluating skeletonized human remains. This abnormality and its relationship to medicolegal cases has not been previously reported in the forensic literature.

Case Studies

Case 1

A decomposed, partially skeletonized, unidentified body was found in a crude campsite in a wooded country area. There was no evidence of violence or criminal acts at the scene. Dental plates and personal effects found about the deceased were identified by a supposed relative. This led to the retrieval of dental and health records from a mental institution where the decedent had been an inmate. Analysis of the skeleton, teeth, and dentures afforded positive identification of a 54-year-old black man. He was known to be a recluse who spent long periods of time in isolated areas. A history of atherosclerotic heart disease was described in his health record.

During the examination of the skeleton an oval defect was found through the body of the sternum. It was located in the center between the attachments of the 4th and 5th costal cartilages and measured 0.5 by 0.7 cm. The edges were rounded, smooth, and covered by cortical bone (Fig. 1).

Case 2

Portions of four skeletal human remains in wooden coffins from an old grave site were discovered during the rebuilding of early 18th-century dry docks. These facilities were the first stone dry docks constructed in the United States and were completed in 1834 [3]. There was no record of a settlement or farm to which the cemetery may have

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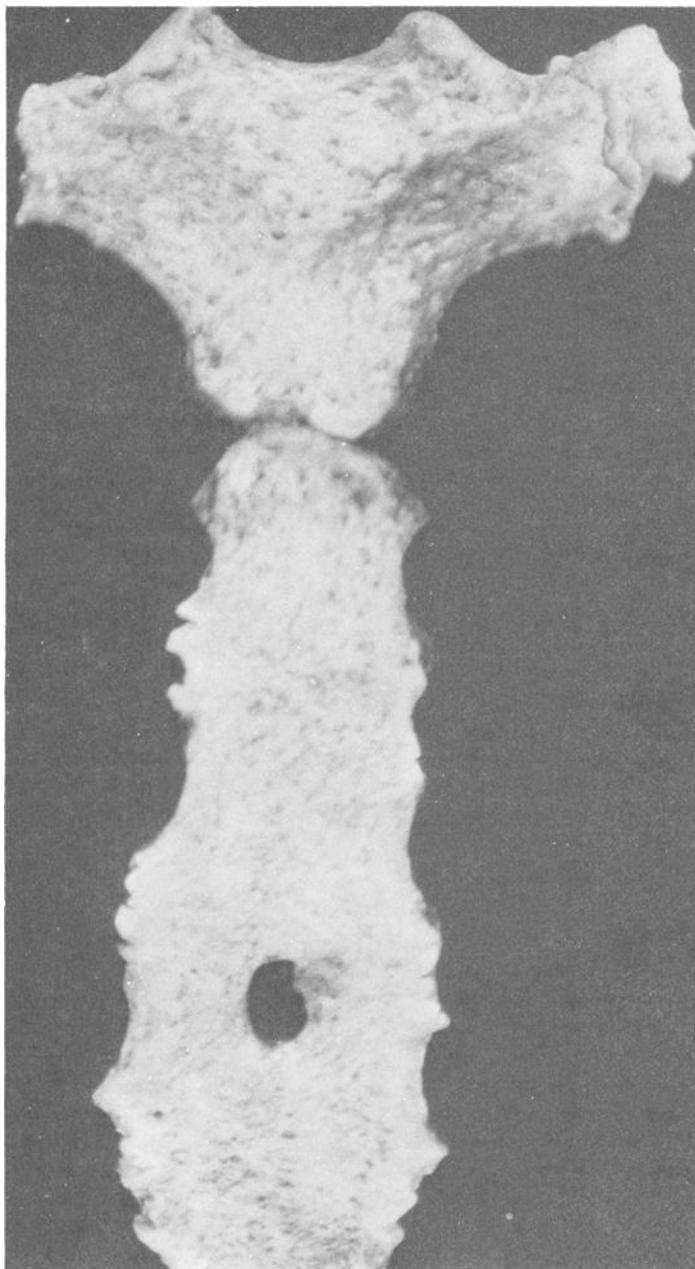


FIG. 1—Gross photograph of the manubrium and body of the sternum from Case 1.

belonged. Anthropological analysis revealed one individual to be a man about 34 to 44 years old, short ($63\frac{1}{4}$ to $65\frac{3}{4}$ in. tall) with mixed racial characteristics (white and Indian or perhaps trihybrid) [4,5]. There was no residual evidence of violence, trauma, or disease process.

In the midline of the lower portion of the body of the sternum between the attachments of the 5th and 6th costal cartilages was an elliptical defect measuring 0.5 by 0.7 cm. The edges of the defect were smooth and well ossified (Fig. 2).

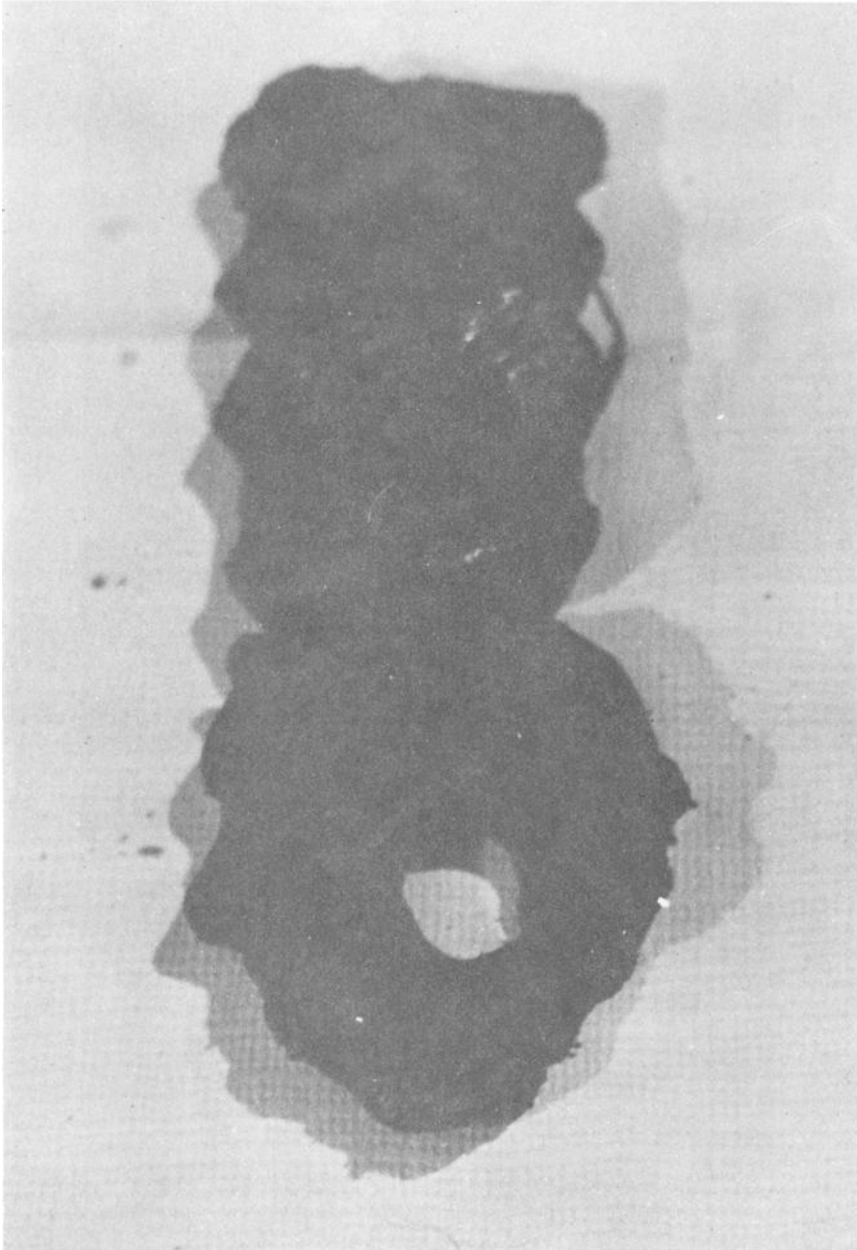


FIG. 2—Gross photograph of the body of the sternum from Case 2. The horizontal cleft in the sternum above the sternal foramen represents a transverse cartilaginous plate between two ossification centers.

Discussion

In the fetus the sternum originally consists of two cartilaginous bars, one on either side of the midline, which become connected to the cartilages of the upper nine ribs on each side. During the eighth week of gestation these bars migrate, converge toward the midline, and fuse with each other, beginning cephalically. By the ninth week the union of the plates is established in the midline and fusion is almost completed to form the manubrium and body of the sternum. The xyphoid process is formed by a caudal extension of the sternal plate. The ossification of the sternum begins from six centers: one in the manubrium, four in the body, and one in the xyphoid process. These ossification centers appear between the articular depressions for the costal cartilages and divide the sternal plate into six transverse pieces. The third, fourth, and fifth pieces are often formed from multicentric ossification centers placed laterally. The third and fourth appear during the fourth and fifth months of fetal life. The fifth usually appears one year after birth. Incomplete fusion of the sternal bars in this area accompanied by eccentric centers of ossification accounts for the relatively rare occurrence of a perforate sternum (sternal foramen), or of a vertical fissure which intersects this part of the bone and which is referred to as *fissura sterni*. Ossification of the sixth part in the xyphoid process does not begin until the 5th to 18th year of life and partial cartilagization may persist well into adult life. Thus, malformations of the xyphoid process due to abnormal fusion and irregular ossification are much more common. Abnormalities of the manubrium and upper portion of the body of the sternum where fusion and ossification occur early in fetal development are much more rare [6].

The cause of death in the two cases described above could not be determined with certainty. In the first case the decedent's medical history of atherosclerotic heart disease, the lack of anatomic evidence of violence or trauma, and the absence of any indication of criminal acts led to the determination of death due to presumed natural causes. In the second case there was no evidence of bony abnormalities other than the sternum which would indicate an antecedent disease process or an unnatural death. The sterna from both cases were X-rayed and there were no demonstrable radio-opaque materials incorporated in the bone around the defects. The position of these defects, in the center of the lower portion of the body of the sternum between the articular surfaces of the costal cartilages, and their characteristic gross appearance are consistent with sternal foramina.

Developmental defects of the sternum are usually not readily detected *in vivo* or in the intact body during postmortem examination, unless they are associated with severe malformations of the rib cage. Perforations or fissures are obscured on routine chest X-rays by the radio-dense structures of the mediastinum and by the superimposed thoracic vertebral column. Abnormalities can be demonstrated at autopsy by holding the removed breastplate between the prosector and a strong light source. If a defect is detected by transillumination, it can be documented by further dissection and by X-raying the breastplate alone. The differentiation between traumatic and congenital defects of the sternum does not present a difficult problem in bodies that are not decomposed. Associated abnormalities, either old or recent, in the surrounding soft tissues and adjacent structures and organs will indicate a lesion caused by injury.

In badly decomposed bodies or skeletonized human remains a sternal defect may present a problem that can lead to misinterpretation and wrong conclusions which have serious consequences. Postmortem artifacts of advanced putrefaction can obscure and mask the gross and microscopic changes of associated trauma. In skeletons the character of the edges of the defect may be altered by scavenger animals or, when evaluating human skeletons which have been exposed or buried for longer periods of time,

demineralization and erosion of the margins of the defect may have occurred. In such instances a careful investigation of the scene and reconstruction of the events preceding death, including examination of any existing medical records, is mandatory to rule out the possibility of an old or recent gunshot wound or a traumatic penetrating lesion caused by an object other than a missile. X-rays of the body or remaining tissue parts and organs are necessary to rule out the presence of a missile. A separate X-ray of the sternum will disclose small metallic fragments about the defect that would be undetectable by gross examination.

Finally, a close examination of even severely macerated specimens should confirm the presence of a sternal foramen. The defect will be located in the midline through the lower half of the body of the sternum. The measurements of the defect will be the same on both the outer and inner surfaces of the bone. No beveling will be present on either surface. Careful examination of the edges with a hand lens will reveal it to be smooth and covered by cortical bone. In specimens which have been exposed to insects, fauna, or marine animals, characteristic erosion, teeth, or claw marks may be present around the foramen, but these should not be mistaken for recent antemortem, traumatic injury.

The sternal foramen is a relatively rare congenital anomaly but when encountered by the pathologist in a case that has medicolegal implications, the failure to recognize it as a developmental abnormality can be a serious pitfall and hazard. The misinterpretation of this bony defect by the nature of its location can result in ascribing a wrong cause and manner of death and frustrating, unnecessary expenditure of time and effort in the investigation of a suspected homicide or suicide.

Summary

Two cases of a congenital anomaly of the sternum which could be misinterpreted as lesions of trauma are presented. The development of this malformation is discussed. Methods of detection, documentation, and the differential characteristics between the developmental abnormality and defects due to injury are outlined.

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