Comparison between Perimortem Blunt Force Trauma identified in Bone during an Autopsy and during an Anthropological Examination of 21 Skeletonized Remains Several Years after Death

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ABSTRACT In this study, the number and location of perimortem fractures identified during the autopsy of 21 fresh cadavers are compared to the number and location of perimortem fractures identified during an anthropological examination of the same individuals several decades after death. These 21 individuals were selected from the skeletal reference collections housed at the National Museum of Natural History and Science (NMNHS, n=20), in Lisbon, and the Life Sciences Department, University of Coimbra (CEI-UC, n=1), Portugal. These individuals are of known cause of death due to violent death associated with a blunt force mechanism. The autopsy reports generated for these individuals were examined at the archives at the National Institute of Legal Medicine and Forensic Sciences, in the Southern Lisbon and Centre (Central) Districts. The anthropological region for which the autopsy has the highest sensitivity is the lower limbs (95%) and injuries to the thorax and pelvic girdle are the ones that become the most underreported during autopsy (0%). Overall, in approximately half of the instances a fracture detected during the autopsy (49%). This research explores the reasons that may explain the discrepancies between the two exams and highlights the fact that fractures resulting from a blunt force mechanism are particularly susceptible to misidentification. If on one hand, the identification of perimortem fractures during an anthropological examination is heavily influenced by taphonomic processes, rendering them undetectable at the time or their interpretation dubious at best, on the other hand, fractures that do not contribute to the cause of death can be missed during the autopsy or only vaguely reported. This study also draws attention to the value of skeletal reference collections where cause and manner of death are known, as they can be an invaluable source of information for the study of skeletal trauma.

INTRODUCTION
The analysis of perimortem blunt force trauma in bone represents a particularly challenging task both done shortly after death in a fresh cadaver, and in skeletonized remains when some time after death has elapsed (1). In either case, a thorough investigation of the skeletal trauma is of utmost importance to the determination of the cause and manner of death. This study reports on the discrepancies found in the number and location of perimortem fractures between the autopsy (shortly after death) and the anthropological analysis (after skeletonization of the remains) performed on a group of decedents who underwent both examinations. The reasons that may explain these discrepancies are briefly explored.

MATERIALS & METHODS
- 21 skeletons curated at the skeletal reference collections housed at the National Museum of Natural History and Science (NMNHS, n=20), in Lisbon and the Life Sciences Department, University of Coimbra (CEI-UC, n=1), Portugal.
- All individuals are of known violent cause and manner of death and the mechanism of injuries is blunt force trauma. Deaths due to other trauma mechanisms (e.g., gunshot wound or sharp force trauma) were excluded.
- Autopsy reports were recovered from the archives of the National Institute of Legal Medicine and Forensic Sciences. No ancillary imaging exams were performed at the time of the autopsy.
- Number and location of perimortem fractures identified at autopsy were compared to the number and location of fractures identified during an anthropological examination.
- Only bones that were present and sufficiently well preserved to perform a macroscopic trauma analysis were considered.
- Sensitivity and specificity of the autopsy were calculated, with the anthropological examination being considered the source of the “true” observations.

RESULTS
For both the autopsy and the anthropological analysis, the most frequent location of skeletal traumatic injuries was the thorax (32%), followed by the neurocranium (20%) and the lower limb (14%). Injuries to the shoulder girdle and the lumbar spine were noted least frequently (1.1%). See Fig. 1 for the distribution of traumatic injuries to the skeleton by anatomical region and by postmortem exam.

DISCUSSION & CONCLUSION
The cases where fractures were reported at the autopsy and not seen during the anthropological examination correspond to 3 fractures to the neurocranium where a fracture line was said to extend over more bones that in fact did; in 2 other cases, fractures were reported at autopsy to affect more leg bones when in fact were only seen on one of the tibia (and not the fibula or the other tibia) during the analysis of the remain; misidentification of bones is the other common occurrence at autopsy, which explain that fractures reported on certain ribs (2), vertebral (1) and hand bones (1) were in fact located on a contiguous bone but not exactly on the reported ones. If such misidentification is considered, only 2 fractures to the lower limbs were over-reported at autopsy, increasing the total specificity of this exam to 99%.

The anatomical region for which the autopsy has the highest sensitivity is the lower limb (Table 1), with the autopsy detecting 99% of the existing fractures; this is followed by the neurocranium, thorax and pelvic girdle (~40%). Injuries to the thoracic and lumbar spine are the ones that become the most underreported during autopsy (Sensitivity: 0%; see Table 1). In only approximately half of the instances a fracture detected during the autopsy (Total specificity: 49%).

At autopsy, non-existing fractures were correctly reported 94% of the times (specificity); the exceptions were 9 fractures that were reported at autopsy but not seen during the anthropological examination.

Table 1: Number of fractures observed and not observed at the autopsy and the anthropological examination. Sensitivity and specificity of detecting fractures during the autopsy in relation to the anthropological examination are presented.

<table>
<thead>
<tr>
<th>Anatomical Region</th>
<th>Fracture</th>
<th>No Fracture</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurocranium</td>
<td>14</td>
<td>1</td>
<td>1.00</td>
<td>0.96</td>
</tr>
<tr>
<td>Splanchocranium</td>
<td>5</td>
<td>0</td>
<td>0.90</td>
<td>0.97</td>
</tr>
<tr>
<td>Shoulder girdle</td>
<td>1</td>
<td>0</td>
<td>0.90</td>
<td>0.99</td>
</tr>
<tr>
<td>Cervical spine</td>
<td>5</td>
<td>0</td>
<td>0.90</td>
<td>0.94</td>
</tr>
<tr>
<td>Thoracic spine</td>
<td>4</td>
<td>0</td>
<td>0.90</td>
<td>0.97</td>
</tr>
<tr>
<td>Pelvic girdle</td>
<td>9</td>
<td>0</td>
<td>0.90</td>
<td>0.99</td>
</tr>
<tr>
<td>Upper limb</td>
<td>9</td>
<td>0</td>
<td>0.90</td>
<td>0.99</td>
</tr>
<tr>
<td>Lower limb</td>
<td>7</td>
<td>0</td>
<td>0.90</td>
<td>0.99</td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
<td>9</td>
<td>0.90</td>
<td>0.99</td>
</tr>
</tbody>
</table>

The low sensitivity (total of 49%) of the autopsy is largely explained by the low rate of “true” fractures reported to the spine. In some cases only a portion of all fractures were reported at autopsy; while in other cases only injuries to the spinal chord were noted, without reporting any bone fractures. Also frequent was the underreport of fractures to the facial bones at autopsy, and the same for the upper limb. Injuries were either missed or underappreciated as they likely did not directly contributed to the cause of death.

Fractures that do not contribute to the cause of death can be missed during the autopsy or be only vaguely reported (particularly where no ancillary imaging studies are done); on the other hand, the identification of perimortem fractures during an anthropological examination is heavily influenced by taphonomic processes, rendering them undetectable at worst or their interpretation dubious at best. This study highlights the fact that certain fractures resulting from a blunt force mechanism are particularly susceptible to misidentification. If on one hand, the identification of perimortem fractures during an anthropological examination is heavily influenced by taphonomic processes, rendering them undetectable at worst or their interpretation dubious at best, on the other hand, fractures that do not contribute to the cause of death can be missed during the autopsy or only vaguely reported. This study also draws attention to the value of skeletal reference collections where cause and manner of death are known, as they can be an invaluable source of information for the study of skeletal trauma.

REFERENCES