Original article:

Investigating antemortem, perimortem and postmortem injuries: forensic implication

Jaiyeoba-Ojigho Jennifer Efe,[1] Odokuma Emmanuel Igho,[2] Umukoro Joysour Mamuyovwi[3]

Abstract:

Context: Skeletal injuries discovered from human remains are classified into antemortem, perimortem and postmortem. Studies that documents injuries of various skeletal elements is of vital importance to forensic anthropologist. **Aim:** This study investigated antemortem, perimortem, postmortem and other injuries caused by various instruments among skeletal elements. **Methodology:** A total of 200 bones of unknown age and gender were studied. Injuries were interpreted based on basic features specific to them and each was described and photographed. Chisquare test was used to show association between skeletal elements and time of injuries. Statistical evaluation was done using SPSS 20 Software Version. Significance was accepted at $p<0.05$. **Result:** The bones from this study showed 17.50% antemortem, 24% perimortemand 57% postmortem. Findings showed that 49.50% of the bones had blunt force injury, 30.50% had sharp force while 20.00% had ballistic injuries. Basic features of antemortem injuries were smooth and round fractured edges within bones. Sharp, smooth fractured edges were observed among perimortem bones in contrast to irregular, blunt fractured edges and uneven discoloration in postmortem bones .Straight line incisions were seen in bones with sharp force injuries,presence of an entrance wound in ballistic injuries while an impact area was discovered in most bones with blunt force injury.Findings showed that there exist a significant association between ante, peri and postmortem injuries in the ulnar,radius and femur bones $(X^2=25.32;13.35;10.11. p=0.000;0.001,0.006)$ **Conclusion:** Bones from this study showed more post mortem blunt force injury.

Keywords: Antemortem; Perimortem; Postmortem; Skeletal injuries; Bones

Introduction:

Bone have been defined as a complex material that constitute both organic (mostly collagen) and mineral components which has been mainly identified as hydroxyapatite .[1]it has been reported that the hydroxyapatite gives bone its hardness and rigidity, while collagen is a connective tissue that provides bone its elasticity and flexibility.[1-4] Bone had also been described as been viscoelastic and anisotropic.[5-6]According to Hiller et al. (2003) the two main types of bone tissue are cortical and cancellous.[3] Cortical bone has been described as the hard hollow cylinder of the bone , responsible for mechanical stability while the cancellous bone as the spongy interior of the cylinder responsible for nutrient storage and transport.[3]

Investigating skeletal injuries and its possible connection with the time and cause of death have been highly imperative in forensic anthropology.[7] Skeletal injuries are classified into cranial and precranial categories based on their position but a different classification system was linked with the time and nature of injuries.[1,7-8] According to some authors, injuries to bones can occur before death (antemortem) ,at or near the time of death (perimortem) or after death (postmortem) describing the time of occurrence.[9-10]

1. Jaiyeoba-Ojigho Jennifer Efe
2. Odokuma Emmanuel Igho
3. Umukoro Joysour Mamuyovwi
   Department of Human Anatomy and Cell Biology, Faculty of Basic Medical Sciences. Delta State University, Abraka, Delta State, Nigeria.

Correspondence to: Jaiyeoba-Ojigho Jennifer Efe, Department of Human Anatomy and Cell Biology, Faculty of Basic Medical Sciences and Delta State University, Abraka, Delta State, Nigeria. Email: efemenaojigho@gmail.com

Injuries present in bones have also been identified as blunt force, sharp force, ballistic and thermal injuries depending on the instruments that caused death and their nature on bones.[1] Scrutinizing injuries in relation to death have been of vital importance to forensic anthropologist providing clues on lifestyles, health, norms and culture of an individual or group of people because they first identify these injuries, determine the relative time at which they were produced and the techniques responsible for their formation. [1-2,8]Spitz et al.(2006) detailed that blunt force trauma was the most frequent type of injury observed during autopsy and the head was the most quotidian location,especially in homicides.[11]

A series of different techniques such as macroscopic and microscopic examination of skeletal elements had been used in investigating injuries or trauma.[12] Macroscopic examination used by several authors and forensic anthroplogists have involved the observation of fractured patterns ,fractured edges, bone tear, osteogenic reactions and adherent materials found within bones,[1,8] while microscopic analysis have been useful as it allowed the observation of bone fracture characteristics, hair and residues of other materials such as metal found within bones.[7] According to Symes et al. (2012) low magnification (Power ×3–40) with a stereoscope is recommended forinquiries from multiple blows or tool impressions.[12] The use of medical imaging had also increased in the investigation of skeletal remains with Dedouit et al.(2014) carrying out a study on visual anthropology and forensic identification using a multidetector CT.[13] Knowledge on injuries or trauma among skeletal elements in Nigeria are limited, hence this study investigated injuries in relation to the time of death and the nature of injuries caused by various instruments among skeletal elements. The study also aimed at examining the association between skeletal elements and the time of injuries.

Methodology:

The study was a descriptive crosssectional study. The work described injuries in relation to death and the nature of injuries or trauma found within bones. A total of 200 bones of unknown age and sex were obtained from Anatomy museum and the gross laboratory of Delta State University, Abraka, Delta State, Nigeria. The bones were sorted into calvariums, skulls, long bones and short bones. Antemortem, postmortem

and perimortem injuries were interpreted based on fracture patterns,fracture edges,bone tear, plastic deformation, adherent materials found within investigated bones. Other injuries such as ballistic, sharp force, blunt force and thermal injuries were explained based on basic features specific to them and each was described and photographed.

Data was represented in frequencies, mean and tables to show distribution of types of injuries.Chisquare test was used to show association between skeletal elements and time of injuries. Statistical evaluation was done using SPSS 20 Software Version. Significance was accepted at $P<0.05$.

Ethical clearance: Ethical consent was sourced from the Research and Ethics Committee of the Faculty of Basic Medical Sciences, Delta State University, Abraka, Delta State, Nigeria on the 14th day of August, 2018 with a reference number DELSU/CHS/ANA/18/13.

Fig 1: Calvarium showing antemortem injury

Fig 2: Skulls showing blunt force injury to head and face

Fig3:Skulls showing perimortem injuries

Fig 4: Ulnar bone showing sharp force injury

Fig 5: Ballistic injury showing an entrance wound

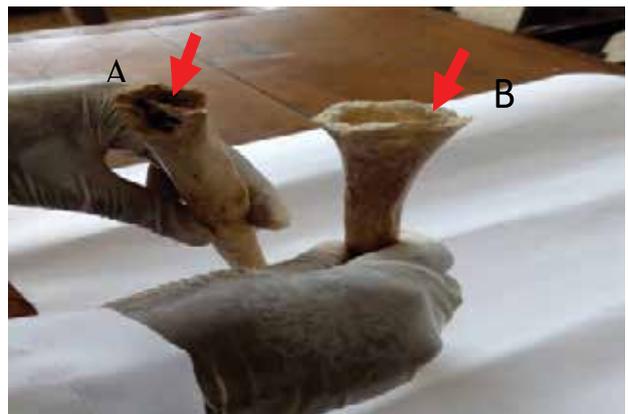Fig 6: Femur bone showing an area of delamination in perimortem injury

Fig 7: Bones showing fracture differences (A) aperi-mortem fracture depicting breakage at an acute angle with sharp fracture edges and (B) a postmortem fracture showing breakage at nearly right angles with blunt fracture edges
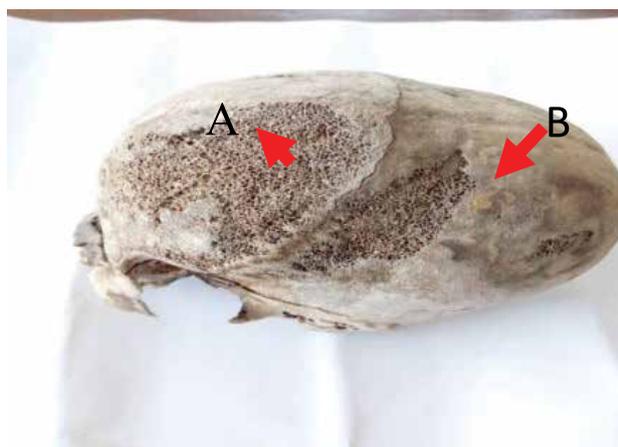
Fig 8: Skull showing (A) cancellous and (B) cortical bone

Table 1 : Percentage distribution of time of injury

Time of injury	Frequency	Percentage
Antemortem	35	17.50
Perimortem	48	24.00
Postmortem	114	57.00
Nil	3	1.50
Total	200	100.00

Table 2: Percentage Frequency Distribution of Nature of Injury

Nature of injuries	Frequency	Percentage (%)
Sharp force	**61**	**30.50**
Blunt force	**99**	**49.50**
Ballistic	**40**	**20.00**
Thermal	**0**	**00.00**
Total	**200**	**100.00**

Table 3: Percentage Frequency Distribution of Time of Injury of various Skeletal Elements

Skeletal Elements	Time of Injury	Frequency	Percent
Calvariums	Antemortem	3	13.6
	Perimortem	6	27.3
	Postmortem	10	45.5
	Nil	3	13.6
	Total	**22**	**100.0**
Skull	Antemortem	3	23.1
	Perimortem	3	23.1
	Postmortem	7	53.8
	Total	**13**	**100.0**

Skeletal Elements	Time of Injury	Frequency	Percent
Ulnar	Antemortem	3	7.9
	Perimortem	8	21.1
	Postmortem	27	71.1
	Total	**38**	**100.0**
Radius	Antemortem	9	19.6
	Perimortem	10	21.7
	Postmortem	27	58.7
	Total	**46**	**100.0**
Femur	Antemortem	12	22.2
	Perimortem	13	24.1
	Postmortem	29	53.7
	Total	**54**	**100.0**
Pelvis	Antemortem	5	18.5
	Perimortem	8	29.6
	Postmortem	14	51.9
	Total	**27**	**100.0**

Fig 1 to 9 illustrates some of the injuries observed among investigated bones from the Anatomy museum and gross laboratory of Delta State University, Abraka, Delta State, Nigeria. Table 1 showed that a total of 200 bones were investigated of which 57% were with postmortem, 24% perimortem and 17.50% withantemortem injuries. Table 2 presented percentage of the nature of injuries found within investigated bones. Findings showed that 49.50% of the bones had blunt force, 30.50% had sharp force while 20.00% had ballistic injuries. Table 3 showed specific bones that were observed for antemortem, perimortem and postmortem injuries. It reported 22 calvaria,13 skull, 38 ulnar, 46 radius, 54 femur and 27 pelvic bones investigated.We observed 13.60% antemortem , 27.30% perimortem and 45.5% postmortem injuries found within the calvaria, while 23.10% each antemortem and postmortem alongside 53.80 % postmortem injuries noticed among the skulls (table 3).

Further findings reported 7.90% antemortem, 21.10% perimortem and 71.10% postmortem injuries discovered within the ulnar bones while the radiaa bones presented 19.60% antemortem, 21.70% perimortem and 58.70% postmortem injuries (table 3). The femur and pelvic bones reported 22.20% and 18.50% antemortem, 24.10% and 29.60% perimortemalongside 53.70% and 51.90% postmortem injuries (table 3). Table 4 explained an association between skeletal elements and injuries in relation to death. Chisquare test showed that the ulnar

Table 4: Association Between the various Skeletal Elements and time of injury

Skeletal Elements	Time of Injury				Chi-Square	P-value
	Antemortem	Perimortem	Postmortem	Nil		
Calvarium	3 (13.64%)	6 (27.27%)	10 (45.45%)	3 (13.64)	6.00	0.112
Skull	3 (23.08%)	3 (23.08%)	7 (53.84%)	-	2.46	0.292
Ulnar	3 (7.90%)	8 (21.05%)	27 (71.05%)	-	25.32	0.000*
Radius	9 (19.56%)	10 (21.74%)	27 (58.70%)	-	13.35	0.001*
Femur	12 (22.22%)	13 (24.07%)	29 (53.70%)	-	10.11	0.006*
Pelvis	5 (18.52%)	8 (29.63%)	14 (51.85%)	-	4.67	0.097
Total	**35 (17.50%)**	**48 (24.00%)**	**114 (57.00%)**	**3 (1.50%)**		

*Indicated statistical significant association between skeletal element and the time of injury

radius and femur bones had a significant association with the time of injury at p<0.05.

Discussion:

Features of antemortem injuries observed from this investigation were the presence of an impact area, rounding and porosity near the fractured edges. Observation was similar to that of Sauer (1984);Aufderheid&Rodrigueze (1998) and Byers (2005).[14-16] According to Byers (2005), porosity near the fractured end is an indication of antemortem injury designating bone activity, reabsoption and fracture healing.[16] Several authors had also reported that the second feature seen among skeletal elements was the slight rounding or remodelling of the fractured edges,indicating that the injury happened at least 7 days prior to death.[8,14-16] Sauer , (1998) quoted an investigation done by Sledzik and Kellyon on the cranium of 257 America civil war victims, where osseous remodeling was observed 1 week after injury.[8] Rounding of fracturededges in antemortem injuries have been associated with bone repair and healing.[17,18]According to Kostantinos&Chara, (2006) the basic attribute of antemortem injuries has been the presence of an osteogenic reaction that can be detected macroscopically, radiographically or histologically.[17] In a study carried out among 127 cranial of America civil war victims for antemortem trauma in form of osteoblastic and osteoclastic signs with lines of demarcation, an osteoclastic reaction was reported 5days prior to injury while both osteoblastic and osteoclastic response was discovered among all victims 6 weeks after injury.[18]

From this study, evidence of perimortem and postmortem injuries observed among skeletal elements were the presence of specific fractured angles and edges perculiar to perimortem and post-mortem injuries. Villa and Mahieu ,(1991) defined a fractured angle as the angle formed by the fractured and cortical bone surface while a fractured edge was described as the structure of the fractured margin.[19]Further findings from this study revealed acute angles among perimortem bones while right angles were noticed among post-mortem bones. Sharp, smooth fractured edges were also observed among perimortem bones in contrast to irregular and blunt fractured edges alongside uneven discoloration in postmortem bones. Findings were not different from a study carried out by Bonnichsen (1979).[20] According to his study among 88 fractures, 88.68% of the perimortem fractures presented oblique or acute angles while 73.68% of the postmortem fractures showed right discontinuity angles.[20]Findings from this study was also in concordance with previous reports by Villa and Mahieu,(1991); Quatrehomme,(1997); Walker ,(2001) while it was in contrast with Marshhall,(1989) and White,(1992) who reported flaked fractures and bone peeling as indicators for perimortem injuries.[19, 21-24]

Plastic deformation was present among some of the studied perimortem bones while broken fragments were attached to some of the skulls. Reports were not different from Jordana et al. (2013).[25]Perimortem trauma on bones have been explained based on the periosteum and other soft tissues present at the time of fracture and when dried, they split with little fragments connected to each other.[9] Several authors reported that wet bone has the capacity to undergo plastic deformation before been fractured than dry bone because of the collagen and moisture

component which makes it flexible and resistant to tension.[5, 8, 10,12,26]

The calvaria, skull, ulnar, radi and femur bones from this investigation had shown more postmortem injuries depicting that most damage occurred after death. Postmortem damage could also be as a result of the air exposed environment which may affect the morphology and microstructure of the bones. Further findings showed that postmortem bones were very dry and brittle,which could be due to decomposition which degrades the collagen component and elasticity.

Other injuries observed from this study were sharp force,blunt force and ballistic injuries. Evidence of sharp force injuries or trauma observed among investigated bones were straight line incisions, illustrating that the injuries were from tools that were edged or pointed. Findings were not different from those of Thompson and Inglis, (2009) who reported that sharp force injuries were characterized from tools edged,pointed or beveated with tool marks in forms of slashes (incisions wider than depth) or stabs (incisions deeper).[27] They further stated that the handedness of an attacker or self-inflicted injuries could be determined by the angle of incision in context to the position of the body.[27]

We observed that blunt force injury was predominant in all bones. The reason could be associated with its cause which includes suicides, accidents and homicides. it has beenreferred to an injury that occurred from a low velocity impact through a blunt object or blunt surface.[28-29] Galloway,(1999) stipulated that they occurred from accidents, sticks and falls with various ranges of fractured patterns depending on both intrinsic and extrinsic factors.[1] Attributes of blunt force injuries from this study were the presence of an impact area, coup, depressed, diastatic, cranial and fascial fractures. Findings were similar to Le Fort (1901) , who carried out a study on 35 cadavaric skulls.[30] He observed three types of fractures (Le Fort I,II,III) associated with blunt force injury which he referred to as the great weak lines.[30] Le Fort I was referred to a separation of the palate from the maxilla as a result of an impact to the face, Le Fort II where the maxilla was detached from the face while Fort III were the maxilla and a section of the mandibular condyles fragmented.[30]The reports of Casali et al.(2014) was also in concordance with our study. Casali et al.(2014) studied blunt force trauma among 307 victims in Milan Italy and observed that 40% of the cases showed cranial fractures while 30% displayed facial fractures.[31]

However findings were different from Ta'ala et al. (2006) who discovered ring and basilar fractures among 85 investigated crania of the Khmer Rouge victims, buried in mass graves at the outermost side of Phnom Penh, Cambodia between 1975 and 1979.[32] Findings were also different from previous studies that observed stellate, remote, hinge and hairlinefractures associated with blunt force injury .[1, 11,33]

We observed the presence of an entrance wound, which was the most prominent feature observed among bones with ballistic injuries. Some of the ballistic bones from this study showed a circumferential and a radially branching fracture around the affected region. Several authors had linked ballistic injuries to the presence of a projectile, fractures associated with an impact from a high velocity, broken materials found within bones or the environment and entrance wounds most times smaller than exit wounds .[2,28-29] This investigation also showed that there exist a significant association between ante, peri and postmortem injuries in the ulnar, radi and femur bones. This indicates that the type of injury observed in bones are due to the mophology and microstructure of the bones.

Conclusion:

Findings from this study had shown that antemortem, perimortem and postmortem injuries were present among investigated bones. Blunt force injury was most common, hence findings will be of vital use in medicolegal investigations of deaths. Findings will also be useful to forensic anthropologist in trying to create a biological profile for an individual or group of people.

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