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Journal:	*International Journal of Osteoarchaeology*
Manuscript ID:	OA-13-0030.R2
Wiley - Manuscript type:	Research Article
Date Submitted by the Author:	n/a
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WEAPON-RELATED CRANIAL LESIONS FROM MEDIEVAL AND RENAISSANCE TURIN, ITALY

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Running title: War injuries from Medieval and Renaissance Turin

Key words: Trauma, weapons, war, Middle Ages, Renaissance

Conflict of interest: all authors declare no conflict of interest

Sponsor

This work was supported by a grant from the ARPA Foundation (www.fondazionearpa.it).

Abstract

Archeological excavations carried out in the square around the Cathedral of S. Giovanni in Turin brought to light burials referable to the Medieval and Renaissance periods. The anthropological examination of the skeletal remains allowed to identify two skeletons from the Medieval period (10^{th}-11^{th} centuries) and four skeletons from the Renaissance age (15^{th} century) showing weapon-related cranial injuries. These *peri-mortem* lesions are indicators of interpersonal aggression and in particular of armed conflicts. The two individuals from the early Medieval period presented three traumas consisting in sharp force lesions caused by blade weapons. As regards the Renaissance sample, the majority of the nine *peri-mortem* injuries were sharp force wounds, followed by a blunt force trauma. These distribution patterns might reflect different fighting techniques, whereas the side distribution and location of the skull trauma provide further indications on the fighting modalities. Identification of the weapons that caused these traumas is suggested. The lack of post-cranial wounds at Piazza S. Giovanni might be explained by the greater attention paid to the head, which was the main target of attack, or by adequate protection of the body through Medieval and Renaissance armours. Otherwise, the wounds in the body would have been found only in the soft tissues, with no involvement of the bones.

Despite the presence of weapon injuries, the results obtained from the study of the Renaissance sample are different from the findings of other contemporary battlefields. It is highly likely that the individuals of the Renaissance age were not young soldiers employed in war episodes and brought back for burial in Turin after battles that had taken place elsewhere. Instead, they were probably individuals who had died in riots or in other violent city episodes, as the historical records for the Renaissance age seem to confirm.

Introduction

Archeological excavations carried out by the Superintendence of Piedmont in the square around the Cathedral of S. Giovanni in Turin brought to light burials referable to the Medieval and Renaissance periods (Pejrani Baricco, 1998; 2003).

In this area the Basilica of the Saviour, attested since the Paleo-Christian age, was reconstructed between the 9th and beginning of the 11th centuries. Outside the northern side of the building a large cemetery, characterized by brick coffin tombs covered with tiles in a double pitch roof, developed over the entire Romanesque age. The burials are East-West oriented, with no equipment elements, except for some buckles in the later levels; reductions and burial re-utilization with superimposition of bodies were quite common. The remains of 113 individuals were studied, including 17 infants and adolescents up to 14 years of age, as well as 96 adults older than 18-20 years; 69 adult individuals were male, 22 females and 5 of indeterminable sex. The unexpectedly low number of child burials and the over-representation of the male sex indicate that this Medieval phase is not referable to the common urban population, but rather to the higher social classes and to particular categories of deceased. This phase of the cemetery is likely to have held the burials of male subjects of adult and advanced age, who can be identified with the members of both the religious and lay urban aristocracy.

During a more recent phase dating back to the Renaissance age the tombs of the early Medieval period were replaced with deep ground pits, where the deceased had been wrapped in shrouds or deposed in wooden coffins. The burials of this period are included in the colonnade of the Gothic age and belong to the 14th and 15th centuries. These tombs seem to correspond to the parish cemetery, and therefore are not the burial site of a specific social class. This phase is testified by archeological and literary evidence, in particular by the casting of three church bells documented in 1470 and by the architecture of the Cathedral which was built in the period between 1491 and 1498.

The anthropological examination of the skeletal remains from Piazza S. Giovanni allowed to identify two skeletons from the early Medieval period and four skeletons from the Renaissance age,

which showed weapon-related cranial injuries. The aim of this study was to investigate these traumas from an osteological perspective, in order to better understand the patterns of interpersonal violence in Medieval and Renaissance in Italy.

Materials and Methods

The cases presented here belong to a large skeletal series of hundreds of individuals, excavated by the Archaeological Superintendence of Piedmont since the 90's, and currently studied by the Anthropozoologica L.A.B. of Livorno (Dr. Elena Bedini and Dr. Emmanuele Petiti) (Bedini et al., 2001; Bertoldi et al., 2001; Fornaciari et al., 2001; Bedini, 2002), which will publish the complete and final work. Of this large series, the six skulls presented here are the only ones with traumas.

The bone remains of the individuals with cranial injuries were submitted to paleopathological study. Sex determination was performed on the basis of the morphologic features of the skull and pelvis (Ferembach *et al.*, 1977-79; Buikstra & Ubelaker, 1994). The age at death was determined on the basis of the pubic symphysis morphology (Brooks and Suchey, 1990), dental wear (Miles, 1963) and sternal rib end modification (Loth & Iscan, 1989). Broad age categories of the type advocated by Buikstra and Ubelaker (1994) were used, namely: adolescent (12–20 years), young adult (20–35 years), middle adult (35–50 years) and old adult (50+ years). The stature was established by the formulas of Trotter and Gleser (1977).

Weapon-related injuries in the skeletons of Piazza S. Giovanni were studied according to the methods of forensic pathology and anthropology. The skeletal wounds were catalogued as *ante-mortem* or *peri-mortem*, according to the presence or lack of healing of the margins; *post-mortem* traumas could be recognized by the lighter colour of the lesions compared to the inner and outer surfaces of the bones (Sauer, 1998).

The description of the cranial wounds is based on the criteria defined in literature (Maples, 1986; Boylston, 2000; Berryman & Symes, 2001; Weber & Czarnetzki, 2001; Novak, 2007; Cohen 2012a and b). Sharp force trauma are caused by bladed instruments, such as swords, daggers, axes and

poleaxes, which produce linear lesions with clean well-defined edges and flat and smooth cut surfaces; blunt force fractures are produced by blunt instruments, including war hammers, maces and top spikes of poleaxes, which leave concentric or radiating fractures with an internal bevel; projectile force trauma are inflicted by projectile weapons, such as arrows and cross-bow bolts.

In the case of sharp force trauma, the direction of the blow was established on the basis of orientation and appearance of the cut surfaces: if the weapon entered a right angle the smooth surface is present on both sides of the bone; if the weapon entered obliquely, the obtuse-angled side shows a smooth surface while the acute side presents signs of flaking (Kjellström, 2005; Lewis, 2008). It is sometimes difficult to distinguish between blunt and projectile forces, but modern forensic work has demonstrated that features such as beveling can be helpful. If blunt trauma bevelling takes place on the inner table, the fracture is caused by forces from outside the cranium. Instead, if high velocity projectile trauma bevelling occurs on the outer table, the fracture is caused by pressure from within the cranium (Berryman & Haun, 1996; Lovell, 1997).

The sizes of the lesions were measured with a digital caliper; the shape and location were recorded by observing the presence of fracture lines and healing signs. An identification of the weapons that produced every single injury is proposed.

Results

Medieval cemetery

Tomb 238

This is a 'capuchin-type' grave with a bottom layer of Roman re-used tiles and bricks; it originally contained the two depositions of a mature man and a child, which were reduced after a period of time so as to allow the deposition of another mature man, who shows evidence of traumatic lesions (fig. 1a).

The skeletal remains belong to a middle adult male, 185 cm tall.

A 7 cm long and 0.8 cm deep-cut lesion is visible along the central portion of the coronal suture; the blade penetrated the bone from a superior angle creating a smooth margin on the posterior surface; the margins are clean, with no traces of bony remodeling (fig. 2). The presence of a triangular lesion on the frontal bone to the right of the bregma, partially exposing the diploe, demonstrates that the blade had remained embedded in the bone and was withdrawn by the aggressor, causing the detachment of a bony fragment. This sharp force trauma was caused by a blade moving from superior to inferior, probably inflicted by an assailant from an upper position.

Tomb 167

This is a 'capuchin-type' grave containing the commingled bones of several individuals, including the remains of an adult man with traumatic injuries, who was reduced to allow the deposition of an adult woman and two children (fig. 1b).

The skeletal remains belong to a young adult male who was 179 cm tall.

A sharp force lesion affected the frontal bone at the level of the left orbit, extending longitudinally for 5.5 cm in length from the supraorbital arch to the frontal bossing and for 2.2 cm in breadth. The lesion, which exposes the diploe and also involves the inner table with a central hole, has a clean surface on the right side, but shows roughening on the left side (fig. 3); this indicates that the trauma was caused by a frontal assailant who had delivered a blow from right to left and then withdrew the blade. No detectable traces of the healing process were found and no fracture lines due to fragmentation of the skull were present.

A second sharp force lesion of 2.5 x 1.5 cm is present in correspondence to the glabella and the left margin of the piriform aperture. The cut consists in a superficial blade wound that removed a section of cortical bone, thus producing a clean surface with irregularities in the left angle. No bony reparation phenomena could be observed (fig. 3). This trauma was caused by a blade blow inflicted from right to left in the middle of the face, probably resulting in the amputation of the nose.

Renaissance cemetery

Tomb 92

This simple grave tomb, which leans against the foundation of the S. Giovanni Dom and can be dated back to 1491-1498, contained the skeletal remains of a middle adult male, 178 cm tall.

This individual shows an impressive traumatic lesion on the left frontal and parietal bones. A large 10.7 x 7.3 cm triangular lesion presents clean margins on its upper edge and irregular margins on its anterior and lower parts, suggesting that the blade embedded in the bone had been withdrawn by the aggressor. Radiating fractures extend from the posterior and inferior angles of the cut, and from the inferior portion of the anterior margin (fig. 4). The injury, detaching the involved bone portion completely, was caused by a sharp force trauma delivered downwards by a right-handed aggressor standing in front of the victim. The lesion was not immediately lethal, as demonstrated by the slight reparative process in the form of fine porosity along the margins of the cut.

Furthermore, a regular 6.5 cm long and 1 mm wide straight sulcus runs along the inferior margin of the lesion; this incision may be interpreted as the result of a surgical operation performed to clean the wound and to remove any bone splinters. Bone remodeling visible along the margin of the surgical incision indicates that the patient tolerated the treatment, but that the cleaning could not arrest the infection and death.

Tomb 74-75-76-77

A unique large grave excavated adjacent to the northern wall of the S. Giovanni Dom, which can be dated back to the period comprised between 1470-1491 (posterior to the casting of the church bells and anterior to the demolition of the Basilica of the Saviour), contained the burials of four male individuals (fig. 5). The direct superimposition of the four skeletons, still in anatomical connection, indicates that the depositions had been performed contemporaneously or within a brief lapse of time. The deceased were wrapped in a shroud, as attested by the position of the bones, the presence

of bronze pins and the narrowness of the pit, which was 50 cm large. Three out of four skeletons show skull injuries.

Skeleton 74

The remains of skeleton 74 belong to an middle adult male, 180 cm tall.

A rhomboidal perforation measuring 12 x 12 mm can be observed on the right tract of the lambdoid suture; the lesion crosses the skull, perforating the endocranium and showing no signs of healing. The external margin presents a clean surface, whereas the internal margin is circumscribed by beveling; no radiating fractures extend from the lesion (fig. 6a-b). This lethal injury was caused by a blunt or projectile force trauma inflicted from behind.

On the outer surface of the right parietal bone, two depressed fractures measuring 2.6 x 1.7 cm and 1 x 1 cm respectively are consistent with healed blunt force traumas which occurred long before death.

Skeleton 76

The remains of skeleton 76 belong to a middle adult male, 172 cm tall.

Two cranial lesions are compatible with traumatic injuries. A quadrangular 5 x 5.5 mm perforation, with no signs of healing, is visible on the right parietal bone at the level of the squamous suture (fig. 7a). The endocranial surface shows internal beveling (fig. 7b). This penetrating injury was caused by a blunt or projectile force trauma inflicted from the right.

The second trauma, a 7 cm long and 4.3 cm wide elliptical lesion is located in correspondence of the right fronto-parietal region, involving the middle portion of the coronal suture. This sharp force lesion, which exposes the diploe for the entire surface except for an outlying hole, is characterized by a clean cut in the superior and posterior region and by a breakage in the inferior portion, compatible with a postero-anterior blow and withdrawing of the blade. The lesion shows no traces of bone remodeling (fig. 7a).

Skeleton 77

The remains of skeleton 77 belong to a young adult male, 175 cm tall.

The skull of this individual shows several traumatic injuries. A 5.5 x 7 mm trapezoid perforation above the right mastoid process crosses the entire bone with no signs of healing (fig. 8a). The ectocranial surface shows clean margins and the endocranial margin of the wound is not circumscribed by beveling. The lesion, similar but smaller than that observed on the right side of the lambdoid suture of skeleton 74, was probably caused by a blunt or projectile force trauma.

On the right fronto-parietal bone, in correspondence of the coronal suture, an elliptical 5.5 x 2.5 cm cut exposes the diploe, but does not involve the inner table (fig. 8b). The sharp force trauma, with clean margins and no healing signs, was probably caused by a blade weapon, and delivered tangentially to the skull surface of a standing victim.

A superficial vertical 5.8 x 2.4 cm cut localized on the left parietal and temporal bones, is the result of a sharp force trauma; the anterior margin of the lesion exhibits a polished blade surface, while the flaked surface is posterior. A radiating fracture departs from the superior edge (fig. 8c). This injury was probably inflicted once the victim had fallen to the ground.

Another sharp force trauma is represented by a 4 cm long, obliquely oriented cut at the base of the right mastoid process; the supero-anterior margin of the lesion has a smooth surface, while the infero-posterior margin shows an irregular surface (fig. 8a). Like the previous cut, this superficial lesion is probably the result of a blow inflicted on a subject fallen to the ground.

Finally, an oval fracture measuring 1.9 x 1.1 cm is evident in the centre of the frontal bone, slightly on the left. The lethal injury, caused by a blunt force trauma, perforated the skull and caused the formation of four fracture lines running away from the hole (fig. 8d); the endocranial surface of the wound shows a 1 cm bevelling, larger in correspondence of the left posterior portion.

It is not possible to establish the sequencing of the five cranial wounds, as there were no interconnecting fracture lines visible.

A healed circular fracture of 2 cm in diameter, consequent to a blunt force trauma occurred long before death, is visible on the left parietal bone.

Discussion

The Turin weapon-related injuries

Peri-mortem weapon-related injuries observed in the skulls of the early Medieval and Renaissance cemetery of Piazza S. Giovanni are a direct indication of interpersonal aggression and in particular of armed conflicts.

A total of three wounds were identified in the skulls of two individuals housed in the Medieval cemetery, whereas a total of twelve wounds were observed in four individuals of the Renaissance age. All the wounds were *peri-mortem*, except for two *ante-mortem* lesions in skeleton 74 and one in skeleton 77, indicating that these individuals had probably experienced other combats before the battle in which they died. No lesions showed differences in colour between the edges of the fracture and the rest of the skull bones, excluding the possibility of *post-mortem* lesions.

The two individuals with cranial wounds from the early Medieval age (10^{th}-11^{th} centuries) were buried in single graves of a cemetery probably reserved to members of the higher social classes, as demonstrated by the overrepresentation of adult male individuals; therefore, it is neither possible to ascertain whether these two individuals died in the same warfare episode nor to refer these findings to a specific war event.

Different is the case of the individuals belonging to the Renaissance period (15^{th} century); the three individuals with weapon-related injuries, who were all found in the same large grave, were probably combatants who had died during the same war episode. Individual 92 was buried in a simple grave tomb dated back to a period slightly posterior to that of the other three combatants. Osseous remodeling observed around the lesion margins indicates that the injury occurred at least two-three weeks prior to death (Sauer, 1998). The incision along the inferior margin is to be referred to a surgical intervention aimed at cleaning the wound. The treatment of cranial lesions has been

attested since Medieval times, as illustrated by treatises, like the one of Roger Frugard dating back to the 12th century (McVaugh, 2006); in this work, reference is made to the removal of loose bone fragments to clean the wound and treat the damage to the dura mater. Osteoarchaeological examples of surgical practice related to cranial injuries from medieval Europe have also been found (Powers, 2005; Weber & Czarnetzki, 2001). However, despite the surgical treatment, the severity of the wound in individual 92 caused the patient's death.

The three traumas of the two individuals from the early Medieval period, were exclusively sharp force lesions caused by blade weapons.

As for the Renaissance sample, the majority of *peri-mortem* injuries consist in sharp force wounds (5) followed by blunt or projectile force traumas (4).

Three out of the nine *peri-mortem* traumas were not penetrating lesions. Internal bevelling developed in three out of six penetrating traumas. Radiating fracture lines were observed in three out of nine *peri-mortem* traumas.

With regard to localization, four of the nine *peri-mortem* traumas occurred on the parietal or fronto-parietal bones, three on the temporal or parieto-temporal bone, one on the frontal bone and another on the occipital bone; these data show that the parietal bones had received the highest number of injuries. As for the side distribution, six lateral wounds were recorded on the right side of the skull (67%), whereas only two were localized on the left side (22%); with predominant laterality of skull injury in the Renaissance sample. The results were compared using the χ^2 test with Yates' correction, and showed no statistical significance ($P<0.13$), because of the very small sample size.

The individuals with multiple *peri-mortem* injuries (76, 77) showed no elements, like radiating fractures from one lesion intersecting with another, that could help understand which wound had been inflicted first. However, a combination of cuts and penetrating injuries on the same skull could be interpreted as a punctured lesion received after the blow, considering that the first blow would have needed to be severe so as to incapacitate the victim, making it superfluous to use blade weapons. The superficial sharp force traumas in skeleton 77 may have been followed by a puncture

wound in the right temporal bone, with the final *coup de grace* that penetrated the skull in the frontal bone.

The lack of post-cranial wounds at Piazza S. Giovanni could be explained with the major attention paid to the head, which was the main target of attack, or with the adequate protection of the body by Medieval and Renaissance armours. Otherwise, the wounds in the body would have occurred only in the soft tissues, with no involvement of the bones. For example, individual 75, buried in the Renaissance multiple grave together with the other three individuals showing *peri-mortem* cranial injuries, may have died in the same combat context, as a result of soft tissue mortal wounds.

Which weapons produced the Turin injuries?

The offensive repertoire of a medieval and a Renaissance soldier was quite extensive, as attested by historical documents (Norman, 1967; Boccia & Coelho, 1975; Barlozzetti & Matteoni, 2008). A weapon can produce more than just one type of injury, and more weapons can cause similar lesions; the lesion results not only from the force with which the blow is delivered, but also from the presence of armours or other equipment protecting the victim; therefore, it is not always possible to match an injury with a particular weapon.

As far as the Medieval sample is concerned, the three traumas observed in the two individuals were exclusively sharp force lesions caused by blade weapons. In this period two main typologies of such weapons, the sword and the axe, were largely diffused. The former produced a thin and clean cut, whereas the latter created larger clefts, possibly accompanied by fractured margins or missing bone fragments; in these cases most of the damaging effect is produced by the blunt action of the instrument mass rather than by the action of the cut. The lesion of skeleton 238 is probably referable to a sword or an axe, judging from the large cleft and detachment of a bone fragment; the two lesions of skeleton 167, probably the result of a similar weapon, were also inflicted by a sword or an axe.

As for the identification of the weapons that caused the traumas in the Renaissance individuals, the thin cuts with clean margins observed in skeleton 77 are typically produced by a sword blade, whereas the impressive wound of skeleton 92, as well as the tangential ones observed in skeletons 76 and 77 could be attributed either to a sword or to a large axe.

It is more difficult to identify the weapons which produced the puncture quadrangular lesions observed in skeletons 74, 76 and 77, as they may have been the result of either blunt or projectile forces (Novak, 2007). These quadrangular wounds could be attributed to pointed blunt weapons such as spears, halberds and daggers, even if it is not known whether they were thrown or used with short handles, spikes of maces, poleaxes or projectile weapons (e.g. arrowhead and cross-bow bolts).

In the literature, similar lesions with no fracture lines and with internal bevelling were attributed to a low-velocity projectile force trauma, in particular an arrowhead or armour-piercing arrowhead, as observed in a Medieval skull (Facchini et al., 2008). Other small quadrangular injuries similar to the ones observed in the Renaissance Turin skulls are documented in the remains from the Medieval battlefield cemetery of Towton, England (A.D. 1461) (Novak, 2007). According to Novak (2007) the largest injuries of this type (superior to 10 mm) match with the profile of the beak of a war hammer, of armour piercing arrowheads or cross-bow bolts, even if cross-bow bolts are unlikely, because high velocity weapons should produce extensive radiating fractures. The arrowhead wounds are distinguished on the basis of a diamond shape nearly obliterated by a circular shape produced by the arrowhead skirt. The smaller quadrangular lesions (inferior to 10 mm) are interpreted as the result of the top spike of a poleaxe. Puncture wounds observed in the remains of the battle of Wisby are all treated as injuries caused by arrows, in order to receive a uniform treatment of the injuries; no attempt was made to distinguish perforations produced by arrowheads, mace spikesor lance-heads (Ingelmark, 1939).

The quadrangular injuries in the Turin skeletons measure 10 mm (74) or less (76 and 77); they show no radiating fractures and the quadrangular shape is not obliterated by the circular shape of the skirt;

furthermore, no defects that might be characterized as projectile exit wounds were observed and no projectiles were recovered from the interior of the skulls.

The quadrangular injuries detected in the Turin skeletons present only internal beveling. This characteristic seems to exclude any projectile force traumas, as modern forensic works demonstrated that with high velocity projectile trauma bevelling occurs on the outer table (Berryman & Haun, 1996; Lovell, 1997). Even if the head protection may have interrupted the impact of an arrow or a cross-bow bolt, which prevented exit from the skulls, these injuries seem to be more compatible with a halberd, spear point or top spike of a poleaxe with square section. Several weapons used in the second half of the 15th century had square section points, but in this period the halberd was very diffused in Piedmont (Boccia & Coelho, 1975; Barlozzetti & Matteoni, 2008).

Finally, the blunt ovoid-shaped lesion in skeleton 77 can be attributed to a bec de corbin (*mazzapicchio*), a type of pole weapon, consisting in a modified hammer head and spike mounted on a long pole, which was popular in medieval Europe; unlike the war hammer, the bec de corvin was primarily used to hit with its beak.

The types of traumas, locations and weapons that may have produced the lesions of the Medieval and Renaissance individuals are summarized in table 1.

Comparison with other battle-related findings

The patterns of *peri-mortem* injuries found in the Piazza of S. Giovanni in Turin can be compared with other contemporary European findings related to the single burials or mass graves of warriors.

Early medieval documentation of skeletal materials with battle-related injuries is scarce. An example of *peri-mortem* cranial injuries of the early Middle Ages comes from Saint Peter's Cathedral in Bologna (Italy); quadrangular perforations on two skulls are interpreted as the result of blows delivered by the beak of a war hammer and a projectile force trauma (Facchini et al., 2008).

The cases dated back to the Renaissance age (16th century) can be compared to the study of the war-related mass grave from the Battle of Towton, AD 1461 (Fiorato et al., 2007), and to the mass grave from the battle of Good Friday, Uppsala, Sweden, AD 1520 (Kjellström, 2005). The skeletal assemblage including 1185 skeletons from the Battle of Wisby, AD 1361 (Ingelmark, 1939) can be taken into consideration, even though it dates back to a century before.

Considering the trauma distribution pattern, a prevalence of cranial lesions compared to post-cranial injuries, like those recorded in the Renaissance Turin sample, was observed both in Towton and in Uppsala: 96% of the skulls in Towton showed weapon-related injuries and only 33% of the individuals exhibited post-cranial wounds (Novak, 2007); 60% of the crania in Uppsala were affected by blade wounds, and only about 18% of the individuals showed post-cranial lesions (Kjellström, 2005). A different distribution pattern was recorded in the skeletal remains from Wisby, where only 40% of the blade wounds were identified in the crania, while the lower legs resulted to be the most affected (Ingelmark, 1939).

These distribution patterns may reflect different fighting techniques: the prevalence of cranial injuries indicates that the head may have been the main target of the assault or that the enemies may have delivered the blows from the back of a horse. Furthermore, the prevalence of cranial versus post-cranial wounds could indicate different protection gears worn by the fighting men, in particular poor quality helmets or ineffective head protections combined with satisfactory armour covering the rest of the body. However, it should be borne in mind that injuries delivered to the body could only affect the soft tissues, with no involvement of the skeletal apparatus.

The side distribution and location of skull traumas provide further indications on fighting modalities. Many studies have demonstrated that the majority of cranial injuries occur on the left side of the head; this distribution is considered indicative of single face-to face combat between right-handed fighters.

In Wisby the majority of lateral cranial injuries occur on the left side (Ingelmark, 1939), in Towton the left side is slightly prevalent among the lateral wounds (Novak, 2007), in Uppsala the injury

location showed no clear dominance, indicating that a frontal attack was not the main pattern of combat (Kjellström, 2005). The distribution of lesions in the Turin sample, with a right side prevalence and with some blows administered from above, seems to indicate that mounted men took part in the combat or that some blows were inflicted to combatants who had fallen to the ground (table 2).

With regard to the number of lesions per skull, the average number of cranial wounds per individual was 4.2 in Towton, 2.7 in Upssala, whereas 55.8% of complete crania showed more than one injury in Wisby; in Turin, two individuals out of four displayed more than a blow in the skull; the large number of wounds indicates intensive combat.

Historical background of the Renaissance injuries

When Turin started to be ruled by the branch of the Savoia dynasty from Chambery in 1418, the city became the capital of the dukedom. The newly established government and bureaucracy were not accepted by the inhabitants and the chronicles report that several riots and tumult took place. Historical sources record several violent episodes dated back to the period of the Renaissance burials. As reported by Benedetto et al. (1997): "At the end of June 1486, when the Duke Carlo I prepared for the war against the Marquis of Saluzzo, a riot among the citizens and the ducal archers caused an undefined number of dead individuals"; and again: "During the night of June 24, 1490, the day of Saint John the Baptist, one of the main counselors of the Duchess Bianca, Louis de Miolans, lord of Serve, was assaulted on the way back from the castle of Porta Bellona, residence of the regent, to the home of Tommaso da Gorzano, where he was accommodated […] the crowd followed Miolans home, broke the door and sacked the house, killing a squire and four servants". This episode is also described by Cognasso (1978): "The affair ended with a violent fight between Piedmontese and Savoyards, who were assaulted by the crowd in the streets of Turin: Ludovico from Miolans, leader of the Savoiards, was offended by some young Turin inhabitants in S. Giovanni Square. The Savoiards, who were driven back, took shelter in the church tower and rang

the bells. The people assembled, riots followed, the house of Ludovico of Miolans was set on fire, some people died in the riot and the city Vicar restored order with difficulty".

This is in the background of the historical events during which the individuals exhumed from Piazza S. Giovanni in Turin underwent the weapon-related cranial injuries we have described. However, it is not possible to relate these traumatic lesions to a specific war episode with certainty.

Conclusions

Three sharp force lesions caused by blade weapons were identified in two individuals from the early Medieval period; in the Renaissance sample, the majority of the nine *peri-mortem* injuries were sharp force wounds, followed by blunt force traumas caused by hand-held weapons. The lack of lesions caused by projectile force lesions and of post-cranial wounds at Piazza S. Giovanni were evidenced.

Despite the presence of weapon injuries, the results obtained from the study of the Renaissance sample are different from the findings of other contemporary battlefields. It is highly likely that the individuals of the Renaissance age were not young soldiers employed in war episodes and brought back to Turin for burial after battles that had taken place elsewhere. As attested by some old wound, they were probably mercenary soldiers, who had died in riots or in other violent episodes that had taken place in the city, as the historical records for the Renaissance age seem to confirm.

Acknowledgments

We would thank Dr. Mario Scalini of the Superintendence for Historical, Artistic and Ethno-anthropological Heritage of the Siena and Grosseto Provinces for his advices on the study of Renaissance weapons.

Permission to reproduce the images was given by the Ministry of Cultural Heritage and Activity.

References

Barlozzetti U, Matteoni S. 2008. *Storia illustrata delle armi bianche dalla preistoria al XX secolo*. Giunti: Firenze.

Bedini E. 2002. L'area cimiteriale della Cattedrale di Torino: notizie archeologiche e primi risultati dello studio dei resti scheletrici. In *Atti del Convegno Antropologia del Medioevo: biologia e cultura*. III Edizione: Le Alpi e la Penisola, Sestino 22-23 ottobre 1999, pp. 55-57.

Bedini E, Bertoldi F, Faggioni PR, Mallegni F, Pagni G, Pejrani L, Subbrizio M, Usai L, Fornaciari G. 2001. Cranial trauma in the individuals from the cemetery of Piazza San Giovanni (Torino). In *Proceedings of the XIIIth European Meeting of the Paleopathology Association*, Chieti, Italy: 18th-23rd September 2000. Edigrafital S.p.A.: Teramo, Italy; 27-29.

Benedetto SA, Comba R, Segre R, Barbero A. 1997. L'economia e la società. In *Storia di Torino, II. Il basso Medioevo e la prima età moderna (1280-1536*), Comba R (ed.). Einaudi: Torino; 421-539.

Berryman HE, Haun SJ. 1996. Applying forensic techniques to interpret cranial fracture patterns in an archaeological specimen. *International Journal of Osteoarchaeology* **6**: 2-9.

Berryman HE, Symes SA. 1998. Recognising gunshot and blunt cranial trauma through fracture interpretation. In *Forensic osteology: advances in the identification of human remains*, Reichs KJ (ed.). Charles C.Thomas: Springfield, IL; 333-352.

Bertoldi F, Bedini E, Faggioni PR, Mallegni F, Pagni G, Pejrani L, Subbrizio M, Fornaciari G, Usai L. 2001. Mortal cranial wounds in the individuals from the cemetery of Piazza San Giovanni (Torino). In *Proceedings of the XIIIth European Meeting of the Paleopathology Association*, Chieti, Italy: 18th-23rd September 2000. Edigrafital S.p.A.: Teramo, Italy; 37-39.

Boccia LG, Coelho ET. 1975. *Armi bianche italiane*. Bramante: Milano.

Boylston A. 2000. Evidence for weapon-related trauma in British archaeological samples. In *Human osteology in archaeology and forensic science*, Cox M, Mays S (eds.). Cambridge University Press: Cambridge; 357–380.

Brooks ST, Suchey JM. 1990. Skeletal age determination based on the os pubis: A comparison of the Acsadi-Nemeskeri and Suchey-Brooks methods. *Human Evolution* **5**: 227-238.

Buikstra J, Ubelaker D. 1994. *Standards for Data Collection from Human Skeletal Remains*. Arkansas Archaeological Survey Research Series No. 44: Fayetteville.

Cohen H, Sarie I, Medlej B, Bocquentin F, Toledano T, Hershkovitz I, Slon V. 2012a. Trauma to the skull: a historical perspective from the Southern Levant (4300 BCE-1917 CE). *International Journal of Osteoarchaeology*, DOI: 10.1002/oa.2258.

Cohen H, Slon V, Barash A, May H, Medlej B, Hershkovitz I. 2012b. Assyrian attitude towards Captive enemies: a s700-year-old Paleo-forensic study. *International Journal of Osteoarchaeology*, DOI: 10.1002/oa.2288.

Cognasso F. 1978. *Storia di Torino*. Giunti Martello: Firenze.

Facchini F, Rastelli E, Belcastro MG. 2008. Peri mortem cranial injuries from a Medieval grave in Saint Peter's Cathedral, Bologna, Italy. *International Journal of Osteoarchaeology* **18**: 421-430

Ferembach D, Schwidetzky I, Stloukal M. 1977-79. Raccomandazioni per la determinazione dell'età e del sesso sullo scheletro. *Rivista di Antropologia* **60**: 5-51.

Fiorato V, Boylston A, Knüsel CJ (eds). 2000. *Blood Red Roses: The Archaeology of a Mass Grave from Towton, AD 1461*. Oxbow Books: Oxford.

Fornaciari G, Bertoldi F, Faggioni PR, Mallegni F, Pagni G, Pejrani L, Subbrizio M, Usai L, Bedini E., 2001. Cranial wounds in the individuals from the cemetery of Piazza San Giovanni (Torino). 1 – The medieval sample. In *Proocedings of the XIII th European Meeting of the Paleopathology Association*, Chieti, 19-23 settembre 2000, pp. 105-107.

Kjellström A. 2005. A sixteenh-century warrior grave from Uppsala, Sweden: the battle of Good Friday. *International Journal of Osteoarchaeology* **15**: 23-50.

Ingelmark BE. 1939. The skeletons. In *Armour from the Battle of Wisby 1361*, Thordeman B (ed.). Kungliga Vitterhets historie och antikvitets akademien: Stockholm; 149–209.

Lewis JE. 2008. Identifying sword marks on bone: criteria for distinguishing between cut marks made by different classes of bladed weapons. *Journal of Archaeological Science* **35**: 2001-2008.

Loth SR, Iscan MY. 1989. Morphological assessment of age in the adult: The thoracic region. In *Age Markers in the Human Skeleton*, Iscan MY (ed). Charles C Thomas Pub: Springfield; 105–135.

Lovell NC. 1997. Trauma analysis in paleopathology. *Yearbook of Physical Anthropology* **40**. 139-170.

Maples WR. 1998. *Trauma analysis by the forensic anthropologists*. In *Forensic osteology: advances in the identification of human remains*, Reichs KJ (ed.). Charles C. Thomas: Springfield, IL; 218-228.

McVaugh M. 2006. *The Rational Surgery of the Middle Ages*. Sismel: Florence.

Miles AEW. 1963. The dentition in assessment of individual age in skeletal material. In *Dental Anthropology*, Brothwell DR (ed.). Pergamon Press: London; 191-209.

Norman V. 1967. *Armi e armature*. Edizione a cura di Arturo Puricelli Guerra, Mursia: Milano.

Novak SA. 2007. Case studies. In *Blood Red Roses. The Archaeology of a Mass Grave from the Battle of Towton AD 1461*, Fiorato V, Boylston A, Knüsel C (eds.). Oxbow Books: Oxford; 240-268.

Pejrani Baricco L. 1998. La basilica del Salvatore e la cattedrale di Torino: considerazioni su uno scavo in corso. In *Archeologia in Piemonte. L'età romana, vol. III. Il Medioevo*, Mercando L, Micheletto E (eds.). Allemandi: Torino; 133-149.

Pejrani Baricco L. 2003. L'isolato del complesso episcopale fino all'età longobarda. In Archeologia a Torino. Dall'età preromana all'Alto Medioevo. In *Archeologia a Torino. Dall'età preromana all'Alto Medioevo*, Mercando L (ed.). Allemandi: Torino; 301-317.

Powers N. 2005. Cranial trauma and treatment: a case study from the medieval cemetery of St. Mary Spital, London. *International Journal of Osteoachaeology* **15**: 1-14.

Sauer NJ. 1998. The timing of injuries and manner of death: distinguishing among antemortem, perimortem and postmortem trauma. In *Forensic osteology: advances in the identification of human remains*, Reichs K (ed.). Charles C. Thomas: Springfield, IL; 321–332.

Trotter M, Gleser GC. 1977. Corrigenda to "Estimation of Stature from Long Limb Bones of American Whites and Negroes" Am. J. Phys. Anthrop. (1952). *American Journal of Physical Anthropology* **47**: 355-356.

Weber J, Czarnetzki. 2001. Brief communication: Neurotraumatological aspects of head injuries resulting from sharp and blunt force in the early medieval period of southwestern Germany. *American Journal of Physical Anthropology* **114**: 352-356.

Table 1 Trauma in the Medieval and Renaissance skeletons from Turin

Skeleton	**Grave**	**Period**	**Time**	**Location**	**Force**	**Weapon**
238	Single	Early Medieval	*Peri-mortem*	Coronal suture	Sharp	Sword or axe
167	Single	Early Medieval	*Peri-mortem*	Left frontal bone	Sharp	Sword or axe
			Peri-mortem	Glabella	Sharp	Sword or axe
92	Single	Renaissance	*Peri-mortem*	Left frontal and parietal bone	Sharp	Sword or axe
74	Multiple	Renaissance	*Peri-mortem*	Right lambdoid suture	Blunt	Halberd, top spike of a poleaxe
			Ante-mortem	Right parietal bone	Blunt	Hammer
			Ante-mortem	Right parietal bone	Blunt	Halberd, top spike of a poleaxe
76	Multiple	Renaissance	*Peri-mortem*	Right parietal	Blunt	Halberd, top spike of a poleaxe
			Peri-mortem	Right fronto-parietal bone	Sharp	Sword
77	Multiple	Renaissance	*Peri-mortem*	Right temporal bone	Blunt	Halberd, top spike of a poleaxe

			Peri-mortem	Right fronto-parietal bone	Sharp	Sword
			Peri-mortem	Right temporal bone	Sharp	Sword
			Peri-mortem	Left parieto-temporal bone	Sharp	Sword
			Peri-mortem	Frontal bone	Blunt	Battle hammer
			Ante-mortem	Left parietal bone	Blunt	Halberd, top spike of a poleaxe?

Table 2 Percentage of injuries on the left side, right side and central portion of the skull in Turin and other battlefield sites of the same period

Site	Left	Right	Central
Wisby	69%	31%	0%
Towton	38%	22%	40%
Uppsala	48%	43%	9%
Turin	22%	67%	11%

Legend to the Figures

Figure 1 The 'capuchin-type' graves 238 (a) and 167 (b)

Figure 2 The sharp force lesion along the central portion of the coronal suture in skeleton 238

Figure 3 Skeleton 167: the two sharp force lesions in the frontal bone at the level of the left orbit (black arrow) and in correspondence of the glabella and the left margin of piriform aperture (white arrow)

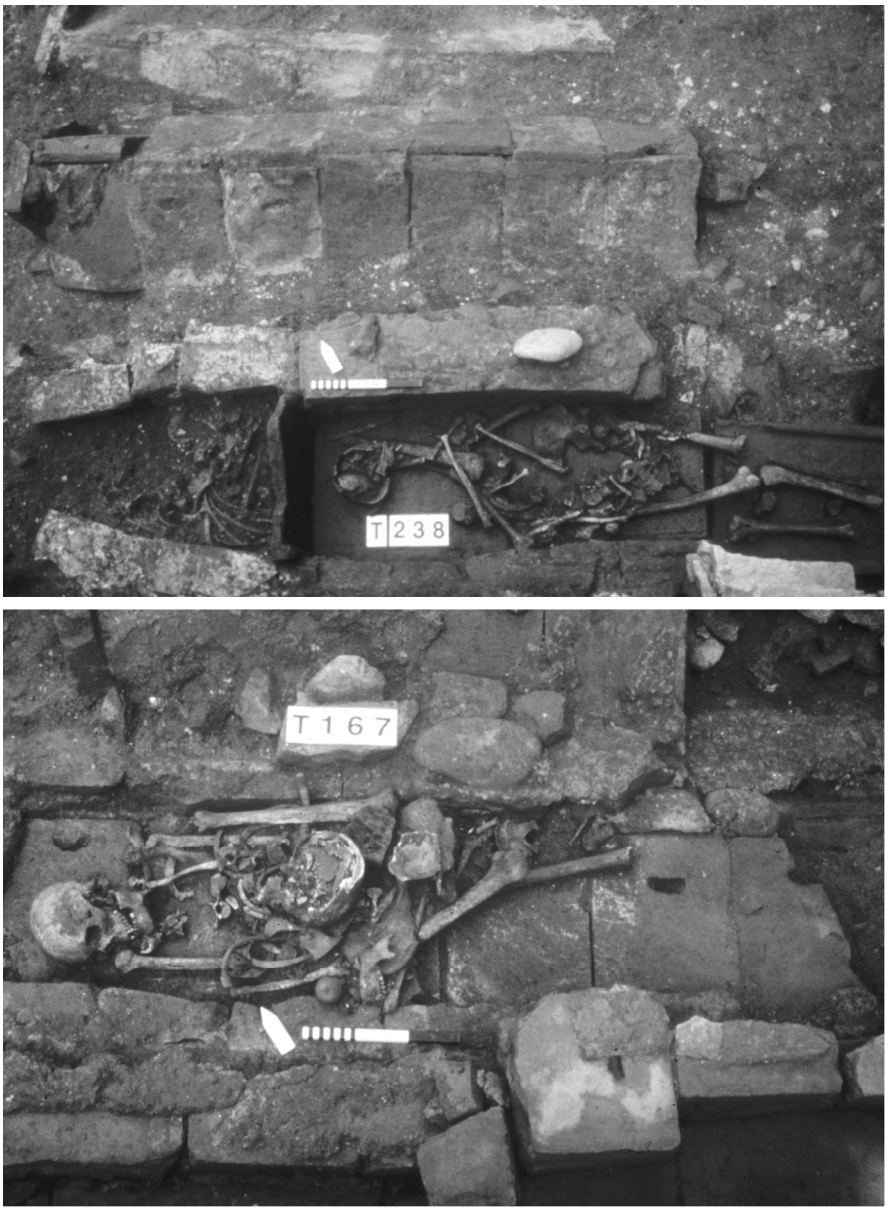
Figure 4 Skeleton 92: impressive triangular lesion on the left frontal and parietal bones (a); slight reparative process in the form of fine porosity along the margins of the cut (b); regular straight sulcus along the inferior margin of the lesion, probably the result of cleaning surgical intervention (c)

Figure 5 The unique large grave in contact with the northern wall of the S. Giovanni Dom containing skeletons 74-75-76-77

Figure 6 Skeleton 74: the quadrangular lesion on the right lambdoid suture (a) and particular of the lesion (b)

Figure 7 Skeleton 76: the sharp force lesion in correspondence of the right fronto-parietal region (white arrow) and the quadrangular perforation at the level of the right squamous suture (black arrow) (a); internal bevelling of the quadrangular perforation (b)

Figure 8 Skeleton 77: trapezoid perforation on the right mastoid process (white arrow) and sharp force trauma at the base of the right mastoid process (black arrows) (a); elliptical sharp force trauma on the right fronto-parietal bone, in correspondence of the coronal suture (b); superficial cut on the left parietal and temporal bone with radiating fracture (black arrows) (c); oval fracture in the center of the frontal bone with four radiating fractures (black arrows) (d)



The 'capuchin-type' grave 238 (a) and 167 (b)

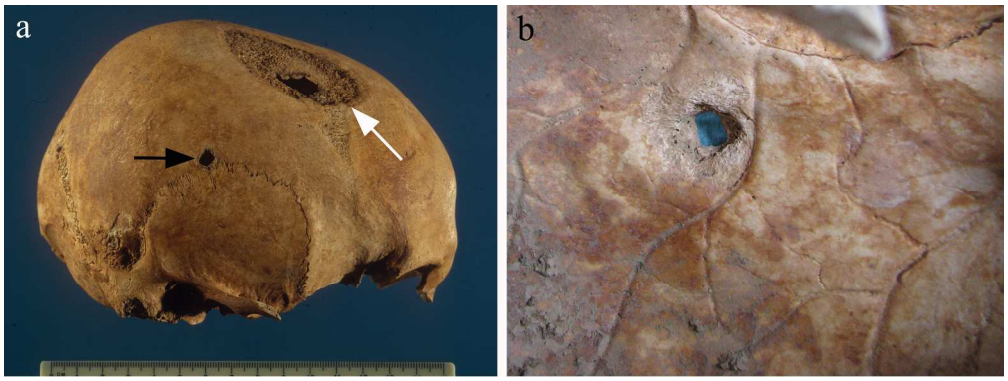
The sharp force lesion along the central portion of the coronal suture in skeleton 238
99x68mm (300 x 300 DPI)

Skeleton 167: the two sharp force lesions in the frontal bone at the level of the left orbit (black arrow) and in correspondence of the glabella and the left margin of piriform aperture (white arrow)
110x137mm (300 x 300 DPI)

Skeleton 92: impressive triangular lesion on the left frontal and parietal bones (a); slight reparative process in the form of fine porosity along the margins of the cut (b); regular straight sulcus along the inferior margin of the lesion, probably the result of cleaning surgical intervention (c)

The unique large grave in contact with the northern wall of the S. Giovanni Dom containing skeletons 74-75-76-77
60x32mm (300 x 300 DPI)

Skeleton 74: the quadrangular lesion on the right lambdoid suture (a) and particular of the lesion (b)



Skeleton 76: the sharp force lesion in correspondence of the right fronto-parietal region (white arrow) and the quadrangular perforation at the level of the right squamous suture (black arrow) (a); internal bevelling of the quadrangular perforation (b)

Skeleton 77: trapezoid perforation on the right mastoid process (white arrow) and sharp force trauma at the base of the right mastoid process (black arrows) (a); elliptical sharp force trauma on the right fronto-parietal bone, in correspondence of the coronal suture (b); superficial cut on the left parietal and temporal bone with radiating fracture (black arrows) (c); oval fracture in the center of the frontal bone with four radiating fractures (black arrows) (d)