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CASE REPORT

PATHOLOGY/BIOLOGY

Inge Morild, M.D.,[1] *Ph.D. and Peer K. Lilleng,* [1]*M.D., Ph.D.*

Different Mechanisms of Decapitation: Three Classic and One Unique Case History

ABSTRACT: Three classic cases and one exceptional case are reported. The unique case of decapitation took place in a traffic accident, while the others were seen after homicide, vehicle-assisted suicide, and after long-jump hanging. Thorough scene examinations were performed, and photographs from the scene were available in all cases. Through the autopsy of each case, the mechanism for the decapitation in each case was revealed. The severance lines were through the neck and the cervical vertebral column, except for in the motor vehicle accident case, where the base of skull was fractured. This case was also unusual as the mechanism was blunt force. In the homicide case, the mechanism was the use of a knife combined with a saw, while in the two last cases, a ligature made the cut through the neck. The different mechanisms in these decapitations are suggested.

KEYWORDS: forensic science, forensic pathology, decapitation, motor vehicle accident, homicide, suicide, long-jump hanging, vehicle-assisted suicide

Decapitation is uncommon in the civilian population. In a forensic practice, however, decapitation is not exceptional. Four cases of decapitation are presented. Three of the cases are classic examples of decapitation, while one case is exceptional. This unique case of decapitation took place in a traffic accident, while the others were seen after homicide, vehicle-assisted suicide, and after long-jump hanging.

The objective of the study was to describe and discuss different mechanisms of decapitation. Through an appropriate scene investigation, together with a postmortem examination, the mechanism of injury can be revealed. For example has decapitation alone in railway incidents been found to be suggestive of suicide, while decapitation together with multiple other injuries is suggestive of an accident. Decapitation in homicides can be seen both as an injury mechanism and as postmortem dismemberment of the body to conceal the victim from being found. Both hanging and vehicle-assisted ligature strangulation may lead to decapitation in suicides. The findings in the different situations are not similar and can be illustrated by the following case histories.

Case Reports

Case 1—Accident

In June 2003, a small Mazda 232 automobile was involved in an accident. In a sharp left curve, the car in high speed had hit the guardrail on the right side of the road. The rail was bended and destroyed. Several road sign poles with warning signs of a sharp curve were on the other side, close to the guardrail (Fig. 1). The head of a young woman with dark blond hair was found close to one of the poles (Fig. 2). Fifty meters from the nearest pole, the car had crashed into a mountain side after first having collided with the guardrail (Fig. 3). The motor of the car was still running. All car doors were closed, and both frontal airbags were released. The window on the passenger side was broken and the glass had fallen out. The windscreen was fractured and covered with blood stains on the passenger side. In the passenger seat, a young decapitated woman was found sitting, leaned forward. The seat belt had not been in use (Fig. 4). There was much blood inside the car on the passenger side. The driver had disappeared, but was later found and arrested.

The autopsy showed a well-built 34-year-old woman with some skin abrasions and bruises on the right arm. On the chin and in the front of the neck, few abrasions were found, indicating the site of impact. There was a little irregular cut in the skin in the front of the neck right below the chin. Around the rest of the neck, the skin was relatively sharp cut along the circumference. On the head, the cut went through the lower temple on both sides, leaving the left ear and parts of the right ear on the neck part of the torso. The occipital bone was fractured, leaving the base of the skull on the torso, and the mandible and tongue connected to the head. The cerebellum and the basal part of the occipital lobe of the brain were bruised. The pons and the medulla were torn and severed. There were fractures in the mandible, but no fracture of the cervical spine (Fig. 5). A toxicology blood screen detected 0.18% of ethanol.

The investigation revealed that both frontal airbags were released at the initial impact. The plastic cover of the right airbag had been pushed into the windscreen which was fractured, but in place. The deceased in the front passenger seat did not wear seat belts. Probably, she already was out of the normal position in the seat when the airbag released. She therefore was pushed against the right front passenger seat window, which then was broken. Owing to the release of airbags and the impact, the head of the female probably was pushed through the open window, and a pole hit the neck. The rounded pole close to the guardrail was intact. The large squared

[1]Section of Pathology, The Gade Institute, The University of Bergen, and Department of Pathology, Haukeland University Hospital, 5021 Bergen, Norway.

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FIG. 1—*Guardrail and warning signs at the place of the initial impact. Arrow points to the place of impact.*

FIG. 2—*The warning sign with poles. Arrow points to the place where the head of the woman was lying.*

FIG. 3—*The car after the accident.*

FIG. 4—*The car with the deceased in the front passenger seat. Safety belt seen behind the deceased.*

FIG. 5—*The head of the motor vehicle passenger. Severance lines through the base of the occipital skull.*

metal sign with the yellow arrow also was intact, but this sign was situated to high up to could have inflicted the injuries. The accident was therefore registered as a blunt force trauma caused by the pole.

Case 2—Homicide

A 54-year-old man disappeared in July 2007. The police suspected a crime, and in January 2008, a dismembered body was found buried in the ground close to a house belonging to a relative. All internal organs were absent.

The body was divided into several parts: head, right and left arm, right and left torso, right and left leg including pelvis. The cut surfaces were mostly sharp, but some places there were irregularities, suggesting that a saw had been used in addition to a knife. The right upper arm was divided below the head of the humerus, and the left arm was separated through the shoulder joint. The sternum and the columna were divided longitudinally with a saw. The pelvis was divided through the sacrum and in front through the symphysis. The body had been transversally cut between the fourth and fifth lumbar vertebrae.

The head was separated from the body by a sharp cut through the skin. The neck was divided between the fifth and sixth cervical

FIG. 6—*Upper part of the humerus, with tool marks, probably from a saw, on the neck of humerus.*

vertebrae. On the front side of the sixth and seventh vertebrae, small tool marks were found, probably made by a saw. No good photograph exists from these marks, but similar tool marks were found on the right humerus (Fig. 6).

The thyroid cartilage was divided horizontally, while the hyoid bone was not injured. The method of separating the head from the body was probably by the use of a sharp knife to cut through the skin, and then a combination of a knife and a saw. The injuries on the vertebrae were very small as they were separated through the vertebral disc.

There were no other antemortem injuries found on the body, and all internal organs had been removed, findings that gave an indication that the perpetrator had some experience as a hunter or a slaughter. No vital reactions were found in connection to the wounds, it was therefore concluded that the dismemberment was performed after death. The cause of death was unknown; however, strangulation was suspected, but never proven. No drugs or alcohol were found in the muscle samples examined.

Case 3—Vehicle-Assisted Suicide

In January 2009, a security guard observed a car on the upper floor of a large parking garage. The car suddenly started and drove in high speed across the parking place before it slowed down and stopped. The rear door was open.

As the car placed itself within a marked parking place, the security guard did not check the car further. Later, the car still with its rear door open, and with the parking lights on, was checked, and a dead man was seen sitting in the front seat. The police and the forensic pathologist arrived shortly after and observed the dead man, sitting in the front seat, with his seat belt on (Fig. 7). The ignition was in "on" position, but the engine was not running, and the manual transmission was placed in second gear. The CD player repeatedly played the same music. The head was lying between the front seats, and a lot of blood was found on the car's window and ceiling. As no tools or rope were found, a police dog searched the area and found a 7-mm-thick, blue nylon rope fastened to a light post, 55 m away from the car (Fig. 8). The whole rope, measuring 28 m was lying by the post. At the free end of the rope a ligature was found. A piece of skin with some hair from a beard was compressed in the ligature.

The head was decapitated through a relatively sharp cut wound in the skin in the front of the neck. In the posterior part, a fragment of skin, together with some subcutaneous tissue had been torn off and was found in the extremely tight ligature. The cut surface of the skin had some small irregularities in the posterior part of the neck, but was difficult to discern from a possible knife cut. The

FIG. 7—*Inside the car. Driver in the front seat. Head lying between the front seats.*

FIG. 8—*Parking place, with the car to the right, and the light post where the rope was found, at the left. Distance between them marked with arrow.*

soft tissue was, however, irregularly cut. Close to the severance plane, a ligature mark was found on the skin (Fig. 9). The severance plane was between the third and fourth vertebrae. There were some small fractures in both of these vertebrae, but not in the vertebral bodies. The thyroid cartilage was cut through the upper part. Both upper horns of the thyroid cartilage, and the hyoid bone were fractured, leaving the upper horns of the thyroid cartilage on the torso. The rope seemed to have found its way through the weakest point of the vertebral column, through the intervertebral disc, which also was sharply divided, however not at the same level as the cut in the skin in the anterior part of the neck. No drugs or alcohol were found in the blood.

Case 4—Long Drop Hanging

In January 2010, a young suicidal man was staying at home together with his mother who was watching him to avoid any suicidal behavior. The young man went upstairs while his mother told him not to do anything stupid. A few minutes later, a noise was heard from above. The mother ran out and found her son's body on the ground while his head was hanging from a rope (Fig. 10). The rope was attached to the fence on the balcony, and a chair was standing close to the fence.

FIG. 9—*Ligature mark below the cut. The cervical columna is cut at a higher level than the skin.*

FIG. 10—*The scene as encountered by the mother. Head hanging from rope. Body on the ground in the snow.*

The victim was 183 cm tall and weighed 109 kg. There were abrasions in skin in the front of the neck. The rest of the skin around the neck was relatively sharp cut. The neck was divided between the fifth and sixth cervical vertebrae, through the intervertebral space, and there were some small fractures in the sixth vertebra. The thyroid gland was attached to the thyroid cartilage on the torso. The rope, a 12-mm-thick, 3.5-m-long nylon rope was lying with a tight ligature around the fourth and fifth vertebrae. The ligature knot was placed on the front side of the neck. The spinal cord was torn close to the pons (Fig. 11).

In the thoracic spine, the frontal ligament was torn between the fourth and fifth thoracic vertebrae, and a partial rupture was found through the front of the articular space between these two vertebrae. There was no damage to the spinal cord in this area.

A few bruises were found on the skin of the torso, owing to the fall, but there were no fractures or other severe injuries. There were no signs of disease. In the blood, a number of drugs were found: Klorprotixen 4 μg/L, *N*-desmethyldiazepam 0.3 μg/L, oxycodone 0.33 μg/L, citalopram 17 μg/L, and olanzapine 0.3 μg/L.

FIG. 11—*The medulla, torn below the pontine level.*

Discussion

Decapitation has been used as an execution method for millennia. The term "capital punishment" is derived from the Latin *caput* "head" referring to the punishment of death by beheading. Beheading typically refers to intentional decapitation, for example, as a means of murder or execution while decapitation can also refer to the removal of the head from a body that is already dead (http://en.wikipedia.org/wiki/Decapitation [accessed September 20, 2011]).

In medieval England, decapitation by sword or axe was sometimes considered the "honorable" way to die, distinguished from a "dishonorable" death for instance on the gallows. In countries where beheading was the usual means of capital punishment, the noblemen would be beheaded with a sword, symbolizing their class as a military caste, thus dying by an instrument of war, while the commoners would be beheaded with an axe (http://en.wikipedia.org/wiki/Decapitation [accessed September 20, 2011]).

The most well-known capital punishment method was the use of the guillotine, a device used for carrying out executions by decapitation. It consisted of a tall upright frame from which a blade is suspended. This blade is raised with a rope and then allowed to drop, separating the head from the body. The device is noted for long being the main method of execution in France and, more particularly, for its use during the French Revolution (1). Nevertheless, the guillotine continued to be used long after the French Revolution in several countries (http://en.wikipedia.org/wiki/Guillotine [accessed September 20, 2011]). Decapitation is quickly and invariably fatal, as brain death occurs within minutes without circulating oxygenated blood. Different types of blades have been made, but usually the blade is of high-quality steel, about 300 mm deep, and is weighted with lead to give a total weight of approximately 40 kg. It falls just over 2.25 m in around 0.75 sec before being brought to rest by a spring mechanism in the block beneath the lunette (http://www.capitalpunishmentuk.org/hanging1.html [accessed September 20, 2011]).

Recently, decapitation has been reported in the news on several occasions. During the Mexican Drug War some Mexican drug

cartels have turned to decapitation of rival cartel members as a method of intimidation (http://www.fpri.org/enotes/200901.grayson.lafamilia.html [accessed September 20, 2011]). Beheadings have also emerged as another terror tactic especially in Iraq since 2003 (http://www.nytimes.com/2004/11/14/movies/14TERROR.html?_r=1 [accessed September 20, 2011]). In these terrorist-style beheadings, it is more usual that the killer first cuts the throat, severing the carotid arteries and jugular veins, the trachea, and the esophagus, causing the victim to bleed out within a minute; then, the spine is slowly severed (http://en.wikipedia.org/wiki/Decapitation [accessed September 20, 2011]).

Decapitation is a relatively rare finding in forensic practice. In high energetic accidents, like explosions, car crashes, and train accidents, decapitation is seen from time to time. Most of the victims are men in the age group 21–40 years (2). Suicidal decapitation is dominated by train suicides (2–4). Some authors state that the severance line in the neck in train-mediated suicide is somewhere between the second cervical vertebra and the first thoracic vertebra (4). Others frequently observe the severance plane at a high level over the fourth cervical vertebra (5). The plane of severance is, however, dependent on the position of the person lying on railway track. Some authors state that in decapitation hangings, the severance plane is between the first and second vertebra, or between the second and the third vertebra (4). In the present case, the severance plane was between the fifth and sixth vertebra, indicating that the severance plane may be anywhere on the neck, depending on the position of the rope, the thickness of the rope, and the circumstances.

In car accidents, railway accidents, or other traumatic incidents, there usually are multiple blunt force injuries to the skin or the bony parts of the neck and not as clear a cut as with the use of knife. This is usually sufficient to state that massive blunt force is the cause of the decapitation. In nearly all cases, the death scene findings immediately give an indication of the cause of death. However, the distinction between suicidal and accidental decapitation in such traumatic incidents should only be made after considering the whole story, investigation of the scene, and autopsy findings like wound edges and possible signs of defense, psychical profile, and toxicological findings (6–8). In traffic accidents and train-mediated suicides, it is usually not possible to calculate the amount of energy or the force that led to decapitation.

In the present accidental decapitation case, the blunt force injuries were relatively moderate. There were some bruises and abrasions on the right hand and arm. On the neck, however, only some small abrasions were found in addition to the sharply cut injuries. It was discussed whether it was possible that the women suffered some cuts in the skin on the neck as she was pushed out of the window and that this allowed for a more clean cut through the rest of the skin when she was hit by the blunt forces from the pole.

In homicides with defensive mutilation, most often a knife, a saw or other sharp instruments have been used in decapitation of the body. Usually, this can be determined by observing tool marks on the cut surfaces of the skin or the bony parts. Often other parts of the body also have been mutilated. There is usually a cut between the vertebrae through the intervertebral disc, and usually no fractures, if a knife has been used. Sometimes the vertebrae have been cut with a saw, which often leaves characteristic tool marks. The combination of death scene findings and autopsy results will usually allow distinguishing between homicidal and other manners of death (9). Absence of vital signs helps in determining whether the victim was alive or not.

In vehicle-assisted suicide, with ligature, the diameter of the rope is of importance. In the present case, the rope was only 7 mm thick, leaving an extremely sharp cut in the skin in the front of the neck. In the posterior part of the neck, some small irregularities in the wound could be seen, but was difficult to separate from a possible knife cut. The soft tissue was, however, irregularly cut. The intervertebral disc was sharply divided; however, not at the same level as the cut in the skin in the anterior part of the neck. Some superficial impression marks were found on the skin below the cut, on the torso.

In decapitation from hanging, body weight and the falling distance are probably the most important factors (10). It must always be checked whether the dynamics to be inferred from the concrete facts can result in decapitation (11). It has been calculated that, independent of the thickness of the rope, axial traction forces of about 12,000 N lead to complete decapitation of human bodies (12). This amount of axial traction force has repeatedly been cited in the literature; however, it is difficult to understand the calculations behind this force, which also is cited in a recent paper (10). More easily understandable calculations are given by Nokes et al. (13). In this paper, drop height tables from the United States and the United Kingdom are presented. From these tables, the length of the rope in judicial hangings could be calculated, the purpose being that no decapitation should occur. The basis for these calculations was that axial energy of 1,700 J was sufficient to result in rapid death without decapitation. In our present case, the victim was 109 kg and the length of rope 3.5 m. The axial traction force should therefore be $109\ kg \times 9.8\ m/sec^2 = 1{,}068\ N$, and the potential energy $1{,}068\ N \times 3.5\ m = 3{,}738\ J$. This would lead to decapitation and still leave an amount of kinetic energy sufficient to impose injuries to the fallen body when hitting the ground. An important factor is the elasticity of the rope. Rope made of hemp is far less elastic than a nylon rope. In addition, before a judicial hanging, the rope was tested to reduce the elasticity, and thus, give the fall a much more rapid stop.

The complete mechanism of decapitation has further been claimed to also be dependent of the radial force from the tightening of the rope. This force has been claimed to be 6.28 times greater than the axial traction forces (12). No explanation for this figure is given. However, the effect would also be dependent of the diameter of the rope.

In our case of vehicle-assisted decapitation, the car weighed 1,400 kg and could accelerate from 0 to 100 km/h in 10.6 sec (a speed of 27.8 m/sec), giving a constant acceleration of $2.6\ m/sec^2$. After 28.1 m (length of rope), the speed would be 12 m/sec after 4.6 sec. It is difficult to calculate the exact forces in this case, as the victim was sitting within the car, with the possibility to move a little, although he was secured to the front seat with seat belts. The front seat was not destroyed and was in normal position. In addition, all the energy was not transferred to the neck as the car continued some 27 m after the trauma.

Conclusion

In cases of decapitation, the scene and the circumstances usually will aid in giving the diagnosis. The forensic pathologist should therefore go to the scene or at least have good photographs available. Appropriate postmortem examination is necessary to reveal the mechanism of injury. Among the cases presented, the accidental decapitation in a car accident is unusual, while the other three cases are more classic examples of decapitation. In this unusual traffic accident, the mechanism behind the injury was blunt force, and a thorough scene examination together with autopsy was necessary to reveal this mechanism. In the other cases, the circumstances will usually also help giving the diagnosis. In suicidal decapitation by ligature, the forces involved will always have to be checked before

a conclusion is made. Sometimes the cut from a ligature can be difficult to separate from a knife wound, but the use of knife usually demands several cuts with different angles and should be possible to discern from the single wound made by the ligature. Tool marks usually indicate postmortem decapitation.

References

1. Po-chia Hsia R, Hunt L, Martin TR, Rosenwein BH, Smith BG. The making of the west, peoples and culture, a concise history, Vol. II: since 1340, 2nd edn. New York, NY: Bedford/St. Martin's, 2007.
2. Mohanty MK, Panigrahi MK, Mohanty S, Patnaik KK. Death due to traumatic railway injury. Med Sci Law 2007;47(2):156–60.
3. Byard RW, Gilbert JD. Characteristic features of deaths due to decapitation. Am J Forensic Med Pathol 2004;25(2):129–30.
4. Tsokos M, Türk EE, Uchigasaki S, Püschel K. Pathologic features of suicidal complete decapitations. Forensic Sci Int 2004;139(2–3):95–102.
5. Racette S, Vo TT, Sauvageau A. Suicidal decapitation using a tractor loader: a case report and review of the literature. J Forensic Sci 2007;52(1):192–4.
6. Zhao D, Ishikawa T, Quan L, Li D-R, Michiue T, Maeda H. Suicidal vehicle-assisted ligature strangulation resulting in complete decapitation: an autopsy report and a review of the literature. Leg Med 2008;10:310–5.
7. Cina SJ, Koelpin JL, Nichols CA, Conradi SE. A decade of train-pedestrian fatalities: the Charleston experience. J Forensic Sci 1994;39(3):668–73.
8. Zoja R, Battistini A, Gentile G. Death with complete decapitation: report of four suicides by train. Am J Forensic Med Pathol 2009;30(3):303–6.
9. Türk EE, Püschel K, Tsokos M. Features characteristic of homicide in cases of complete decapitation. Am J Forensic Med Pathol 2004;25(1):83–6.
10. Töro K, Kristóf I, Keller E. Incomplete decapitation in suicidal hanging—report of a case and review of the literature. J Forensic Leg Med 2008;15(3):180–4.
11. Wehner HD, Schulz MM, Wehner A. Dynamics of decapitation after falling in a self-tightening rope noose. Arch Kriminol 2006;4:108–22. [Article in German].
12. Rabl W, Haid C, Katzgraber F, Walser B. Hanging with decapitation. Case report—biomechanics. Arch Kriminol 1995;195:31–7. [Article in German].
13. Nokes LD, Roberts A, James DS. Biomechanics of judicial hanging: a case report. Med Sci Law 1999;39:61–4.

Additional information and reprint requests:
Inge Morild, M.D., Ph.D.
Section of Pathology
The Gade Institute
The University of Bergen
and Department of Pathology
Haukeland University Hospital
5021 Bergen
Norway
E-mail: inge.morild@gades.uib.no