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A New Approach to Upper Cervical Injuries

Routine autopsy techniques are standard, with a few minor variations, and give fully satisfactory results for most autopsies. However, there are occasional circumstances such as in the evaluation of upper cervical injuries in which the standard techniques give unsatisfactory results.

Standard technique, as described in the "Autopsy Manual" of the Armed Forces Institute of Pathology [*1*], describes removal of the brain from above after transection of the upper cervical cord, followed by removal of the spinal cord by either the anterior or posterior approach. In the anterior approach the dissection and removal of the cervical cord is almost completely blind, with absolutely no visualization of the surrounding bones, ligaments, and soft tissues. In the posterior approach the spinal cord is visualized in situ along with the bones, ligaments, and soft tissues; however, it is almost impossible to separate the cord damage caused by postmortem removal of the brain from recent antemortem injury.

Sohn [*2*] in 1972 described a technique for removal of the brain and spinal cord in one piece. He opens the skull in the usual manner, but rather than cutting the upper cervical cord carefully incises the dura around the foramen magnum. Using the anterior approach he removes the bodies of the vertebrae up to C2 and loosens the cord. Finally he pulls the brain and spinal cord in one piece through the top of the skull. This approach succeeds in removing the brain and spinal cord in one piece and is adequate if the upper cervical pathology is confined to the cord; however, it is still woefully inadequate if careful examination of the upper cervical region including the atlas, axis, base of skull, ligaments, and soft tissues is necessary to elucidate the pathology.

It is not uncommon to have death result from upper cervical injuries. To examine these cases adequately the author has developed a technique that allows examination of the brain, spinal cord, and surrounding structures in situ. The brain and spinal cord are easily removed in one piece.

Method

Although removal of the brain and spinal cord can be done either before or after removal of the internal organs, the body can be better positioned and the procedure is much neater when the autopsy is begun with dissection and removal of the brain and spinal cord. The body is placed on the autopsy table in the prone position. The head block is placed under the chest in the position that will give maximum elevation to the chest, raising the body enough so that the forehead is the only part of the head touching the table, thus protecting the features from injury. The cervical spine is stretched. The pectoral girdles tend to fall laterally, giving better exposure to the thoracic vertebrae.

A midline longitudinal incision is made through the skin and subcutaneous tissue start-

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ing about 3 cm behind the normal hair line and extending to the sacrum (Fig. 1). The scalp is dissected laterally, exposing the parietal bones, parts of the temporal bones, and almost the entire occipital bone. The spinous processes and the neural arches of the vertebrae are exposed by dissecting away the back muscles.

The skull is sawed from one lateral aspect of the foramen magnum to a level just superior to the ear, across the superior portion of the skull at approximately the level of the coronal suture to a point just superior to the other ear and back through the other lateral aspect of the foramen magnum (Fig. 2). The lamina of the vertebrae are sawed through. A transverse cut of one of the inferior lumbar neural arches is made as in the standard posterior approach (Fig. 3). The sawed portions of the vertebral arches are removed, starting inferiorly and working toward the head. At the foramen magnum the dura is incised. The sawed piece of skull is lifted off. Thus much of the superior and the entire posterior portions of the brain, the entire dura-covered spinal cord, and surrounding structures are exposed (Fig. 4).

Many lesions of the posterior portion of the brain, especially the cerebellum, can be observed in situ. Any portion of the dura of the cord can be incised if observation of the spinal cord in situ is desired at this stage. However, it is better to leave as much as possible intact since an intact dura makes it easier to remove the spinal cord without damage.

To remove the brain and spinal cord, start cutting the attachments of the spinal dura and nerves at the level of the cauda equina and work superiorly into the skull, ending with severance of the optic and olfactory nerves and the internal carotid arteries. The brain and dura-covered spinal cord can be easily lifted out.

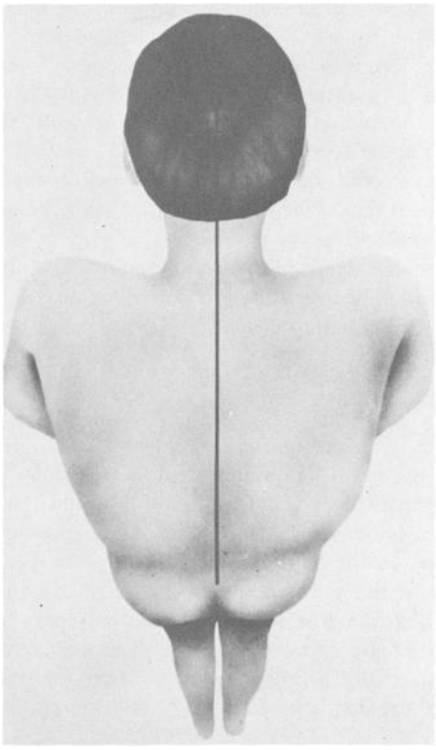

FIG. 1—*Illustration of a properly positioned body. The line extending from the head down the back indicates the location of the skin incision.*

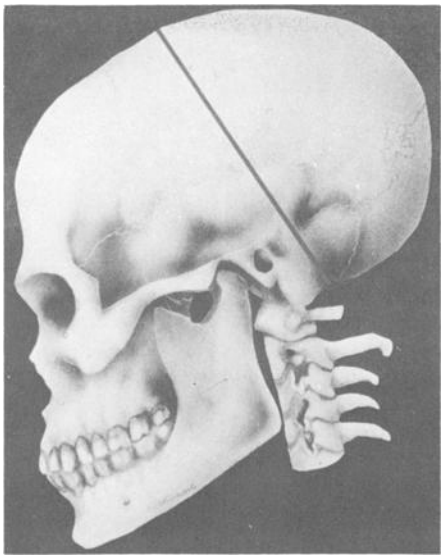

FIG. 2—*Lateral-view illustration showing the location of saw cuts of the skull.*

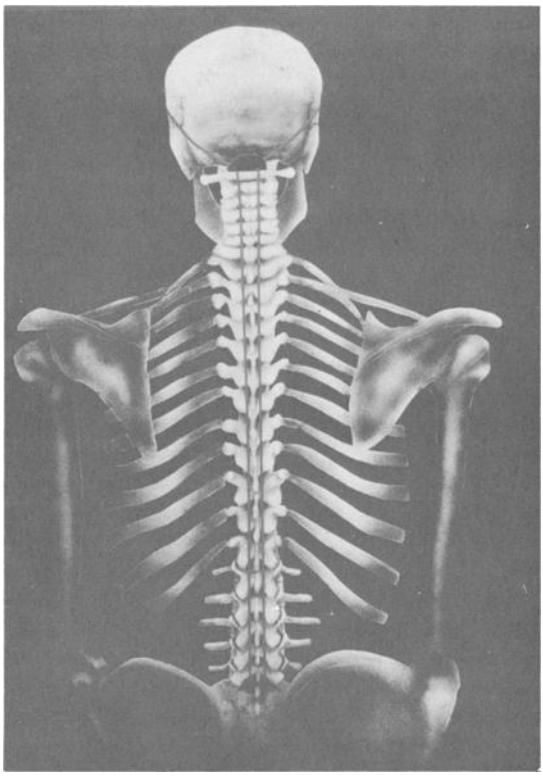

FIG. 3—*Posterior-view illustration showing the location of saw cuts of the skull and vertebral column.*

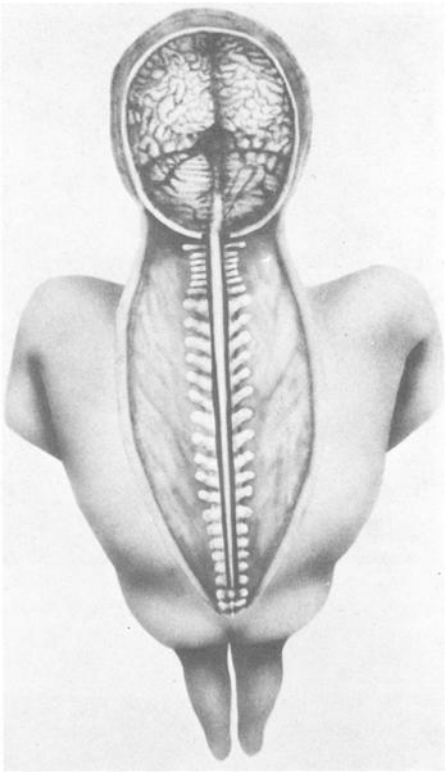

FIG. 4—*Illustration showing exposure of brain and spinal cord in situ after the removal of posterior portion of the skull and neural arches.*

The posterior longitudinal ligament of the vertebrae is exposed and should be examined for evidence of new or old injury or other lesions. It is relatively easy to dissect the anterior arch of the atlas and the odontoid process of the axis for fractures and ligamental tears.

Some cases are presented below in which the above approach to the brain and spinal cord has been found to be useful.

Case Reports

Case 1

A 63-year-old white housewife was in the front passenger seat of a car which was hit broadside by a stolen passenger truck as the car made a left turn onto a busy highway from a shopping center. She was killed instantly. At autopsy her head was unusually mobile. There were fractures of the axis and atlas and partial transection of the spinal cord in this area. There were also many severe internal injuries, including a laceration of the heart.

Case 2

While an elderly white housewife was crossing the street, she was hit by a car going an estimated 105 to 113 km/h (65 to 70 mph) and she was instantly killed. At autopsy there

was marked crepitation of the neck near the occiput, and the head flopped on the neck. There were multiple fractures around the foramen magnum and transection of the upper cervical cord 1 cm from the medulla. There were many other injuries, including lacerations of the aorta.

Case 3

A 40-year-old white housewife was admitted to the hospital unconscious. On the previous evening the decedent and her ex-husband went to a pizza parlour for pizza and beer. On the way home they argued. He stopped the car, shot her in the chest with a .22-caliber pistol, and then took her home. She was unconscious (which the family attributed to being drunk) and was put to bed. When she was found to be still unconscious the next morning, the gunshot wound with blood oozing from it was discovered, and she was taken to the hospital. Attention at the hospital was focused on the chest injury; the loss of consciousness was attributed to anoxia secondary to the chest wound. Two days later decerebrate rigidity occurred. She died eight days after the injury, never having regained consciousness.

At autopsy the bullet tract was found to have passed through the upper lobe of the right lung. The bullet was found in the subcutaneous tissue inferior to the scapula. Moderate bronchopneumonia and emphysema were present. She had severe acute bilateral salpingitis with a large amount of yellow pus free in the pelvis.

While preparing to open the skull in the usual manner, the pathologist noted that despite rigor mortis elsewhere, the head flopped around on the neck, much like a rag doll. The body was immediately turned over, and with the method given above, the brain and spinal cord were explored and removed. The occipital veins in the subcutaneous tissue and muscles of the upper cervical and occipital regions were distended with dry, dark-red thrombi and looked like a bunch of 0.5-cm-diameter dark-red worms. The skull and atlas were dislocated anteriorly on the vertebral column because of both torn ligaments and a fracture of the odontoid process of the axis. All the dural sinuses, meningeal arteries, cerebral arteries, and cerebral veins were thrombosed. There was extensive softening and pinkish discoloration of the brain and spinal cord down to C3. There was no anatomic evidence of transection of the cord at the site of injury.

At the trial it came out that the ex-husband knew he had broken her neck at the time he shot her but had not told the family or police.

Case 4

A middle-aged white male with severe ankylosing spondylitis developed complete ankylosis of the vertebral column prior to his automobile accident in March 1966. After four days' hospitalization, he was discharged with no neurologic findings. The following night he slept at home, sitting in a chair. He awoke with quadriplegia that persisted until his death in April 1977. X-rays showed sharp angulation of the spine at the junction of C6 and C7.

Because of the old spinal cord injury, it was decided to use the approach given above for the autopsy. The spinal cord was in continuity, but of extremely small diameter at the site of injury (Fig. 5). The body of C6 showed a healed fracture with misalignment of the fragments (Fig. 6).

Discussion

The upper cervical injuries in the first three cases could be much better evaluated by the above approach than by conventional approaches.

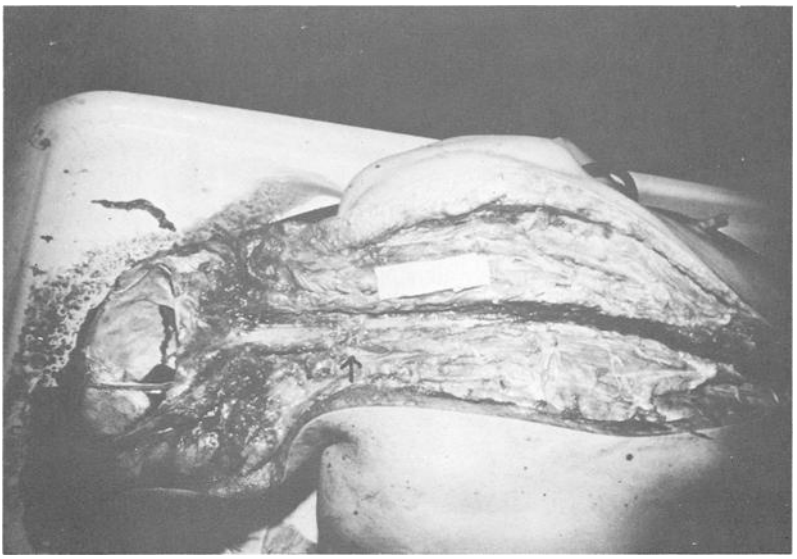

FIG. 5—*Photograph from Case 4 showing the brain and spinal cord in situ after the removal of the posterior portion of the skull and neural arches. The arrow points to an area of narrowing of the spinal cord secondary to an old injury.*

FIG. 6—*Photograph from Case 4 showing the skull and vertebral column after removal of the brain and spinal cord in one piece. The arrow indicates an area of an old injury with misalignment of vertebral bodies.*

In Case 3 the dislocation at the time her husband "broke her neck" must have stretched the vertebral arteries and veins, causing intimal damage and initiating the thrombosis which spread to the subcutaneous, muscular, and cerebral vasculature, which in turn led to decerebrate rigidity and encephalomalacia. Since the pathology of the spinal cord was

above C3, yet she never needed a respirator, it is obvious that the spinal cord was not functionally transected above C3. Therefore death was due to damage to the cerebral arteries and veins with subsequent thrombosis rather than direct cervical injury.

The injury in Case 4 was in an area that could have been adequately visualized by the standard posterior approach. It is included because it is the only one of these cases with good photographs.

Under what circumstances should this approach be used? Obviously it should be used when there is a known injury to the upper cervical region. In some cases the nature of the trauma makes one very suspicious. However, there is a considerable number of cases, such as Case 3, where there is nothing in the history to alert the pathologist to the probability of upper cervical injury. It is here that one becomes highly suspicious during external examination or when preparing to open the skull in the usual manner. By the time of autopsy, rigor mortis has almost always either begun or is in full force. However, in traumatic injury to the upper cervical spinal cord, there is usually concomitant tearing of ligaments, muscle damage, and fractures, preventing the appearance of rigor mortis in this area. The net result is that the head flops about on the neck, much like that of a rag doll. The head has to be immobilized before the skull can be opened in the usual manner. When this floppiness is present, the body should be immediately turned over and the above approach used to explore the upper cervical region. Once decomposition has set in everything flops, so in these cases a floppy head alone is no indication for this approach.

Summary

Severe injuries to the upper cervical region can be the cause of death. Standard autopsy techniques are inadequate for examination of this area. Therefore a technique has been developed that gives excellent visualization and allows removal of the brain and spinal cord in one piece.

With the body prone a midline incision is made from the top of the head to the sacrum. The skull is sawed in a circle from one side of the foramen magnum around the top of the skull to the other side of the foramen magnum. The lamina of the neural arches of the vertebral column are sawed. With the removal of the piece of skull and the posterior portions of the neural arches, the posterior half of the cerebral cortex, cerebellum, and entire spinal cord are exposed. The entire brain and spinal cord can be removed as a unit.

Cases are selected by history, X-ray examination, or floppy head. Four cases in which this approach has been helpful are briefly mentioned.

Acknowledgment

The author wishes to express her appreciation to Eleanor Tomasulo of the Department of Biomedical Communications of the West Virginia School of Osteopathic Medicine, Lewisburg, W. Va., for making the illustrations used in Figs. 1 to 4, and to Eleanor Tomasulo and Gerry Allen Briggs of the same department for the preparation of the photographs.

References

[*1*] "Autopsy Manual," Armed Forces Institute of Pathology, Washington, D.C., 1960, pp. 21-27.

[*2*] Sohn, D., "Removal of the Spinal Cord in Continuity with the Brain at Autopsy," *American Journal of Clinical Pathology*, Vol. 58, No. 5, 1972, pp. 596-597.

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Erratum

Hooper, A. D., "A New Approach to Upper Cervical Injuries," *Journal of Forensic Sciences,* JFSCA, Vol. 24, No. 1, January 1979, pp. 39-45. On p. 44, Figures 5 and 6 were transposed. The photograph appearing above the caption for Figure 5 is actually Figure 6, and vice versa.