

RB
57
.N65

DOT-HS-803 287

NECK INJURY ASSESSMENT PROTOCOL

Thomas T. Noguchi, M.D.
Irving Rehman, Ph.D.

Chief Medical Examiner-Coroner
Hall of Justice
Los Angeles, California 90012

Contract No. DOT-HS-6-01476
Contract Amt. \$19,956.43



**MARCH 1978
FINAL REPORT**

This document is available to the public through
the National Technical Information Service,
Springfield, Virginia 22161

Prepared For
**U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Washington, D.C. 20590**

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

KD
57
1. N65

Technical Report Documentation Page

1. Report No. DOT-HS-803 287		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Neck Injury Assessment Protocol.				5. Report Date March 1978	
				6. Performing Organization Code	
7. Author(s) Thomas T. Noguchi, M.D., Irving Rehman, Ph.D.				8. Performing Organization Report No.	
9. Performing Organization Name and Address Chief Medical Examiner-Coroner Hall of Justice Los Angeles, California 90012				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No. DOT-HS-6-01476	
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration 400-7th Street, S.W. Washington, D.C. 20590				13. Type of Report and Period Covered Final Report Oct. 1976-March 1978	
				14. Sponsoring Agency Code	
15. Supplementary Notes					
16. Abstract This is a protocol of suggested autopsy procedures based upon an autopsy examination and study of twenty-two motor vehicular deaths, studied at the Department of Chief Medical Examiner-Coroner, County of Los Angeles, California.					
17. Key Words Autopsy, Radiology, Forensic, Pathology			18. Distribution Statement This Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161		
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 39	
				22. Price	

METRIC CONVERSION FACTORS

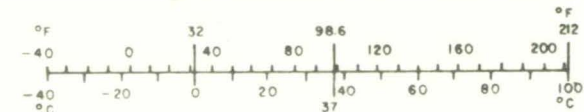
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	*2.5	Centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
in ²	square inches	6.5	square centimeters	cm ²
ft ²	square feet	0.09	square meters	m ²
yd ²	square yards	0.8	square meters	m ²
mi ²	square miles	2.6	square kilometers	km ²
	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
VOLUME				
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft ³	cubic feet	0.03	cubic meters	m ³
yd ³	cubic yards	0.76	cubic meters	m ³
TEMPERATURE (exact)				
F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	C

*1 in = 2.54 exactly. For other exact conversion (and more detailed tables) see: *NBS Mon. Publ. 280, Units, Weights and Measures*, Dec. 2, 1975, NIST, Gaithersburg, MD 20899.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares (10,000 m ²)	2.5	acres	
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m ³	cubic meters	35	cubic feet	ft ³
m ³	cubic meters	1.3	cubic yards	yd ³
TEMPERATURE (exact)				
C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	F



NECK INJURY ASSESSMENT PROTOCOL

Principal Investigator:

Thomas T. Noguchi, M.D.
Chief Medical Examiner-Coroner, County of Los Angeles

Research Coordinator and Forensic Anatomist:

Irving Rehman, Ph.D., Professor of Anatomy and
Deputy Coroner, County of Los Angeles

Neuroradiologist:

Grant Hieshima, M.D., Chief of Neuroradiology
Harbor General Hospital, Los Angeles, California

Additional Contributors:

Verity S. Grinnell, M.D.
C. Mark Mehringer, M.D.
Department of Radiology, Harbor General Hospital

Neuropathologist:

Hideo H. Itabashi, M.D., Head, Neuropathology
Harbor General Hospital, Los Angeles, California

Additional Contributor:

Randall W. Smith, M.D. (Neurosurgeon)
Professor, Division of Neurosurgery
University of California, San Diego, California

Forensic Pathologist:

Robert Bucklin, M.D., J.D.
Deputy Medical Examiner, County of Los Angeles (formerly)
Now Chief Medical Examiner, Travis Co., Austin, Texas

Grant Coordinator:

Ronald L. Taylor, Ph.D.
Director of Forensic Laboratories and
Department Grants Coordinator, County of Los Angeles

NECK INJURY ASSESSMENT PROTOCOL

Protocol of suggested autopsy procedures based upon an autopsy examination and study of twenty-two motor vehicular deaths, studied at the Department of Chief Medical Examiner-Coroner, County of Los Angeles, California.

<u>TABLE OF CONTENTS</u>	<u>pages</u>
Preliminary Examination	1-6
Specialized Layer-by-Layer Head and Neck Autopsy	7-13
Examination of Brain and Spinal Cord	14-25
Radiological Examination of Head and Neck	26-33

NECK INJURY ASSESSMENT PROTOCOL

TASK I

Develop a tentative autopsy protocol.

A protocol of suggested procedures based upon an autopsy examination and study of twenty-two motor vehicular deaths is submitted.

The procedure followed in the detailed examination of the head and neck consisted of an examination of the victim for external contusions, abrasions, lacerations, etc. as part of the general autopsy.

This was followed by the radiological examination and upon completion of this portion of the autopsy, the detailed step-by-step layer autopsy dissection of the head and neck was then performed by the Forensic Anatomist. This portion of the autopsy included the laminectomy of the cervical spine (not including C1 and C2) and the removal of the brain and cervical spinal cord as a unit for further examination by the Neuropathologist.

A final evaluation was made after the accumulation of the data from the surface examination, general autopsy, radiological examination, step-by-step layer autopsy dissection, and neuropathology examination.

A general estimation of the relative value of each step in this extended procedure was made.

TASK II

1. Detailed autopsies of the head and neck had been completed on a series of five non-vehicular cases following the procedure as outlined in Task I.
2. • Seventeen crash-involved cases were studied utilizing:
 - a. Radiological studies of the head and neck, taken in antero-posterior, lateral, oblique and pillar views. Vertebral artery angiography was performed in three cases.
 - b. Routine autopsies of the chest and abdomen were performed on all motor vehicular cases.
 - c. A layer-by-layer autopsy dissection of the head and neck was performed on each case utilizing an anterior and posterior approach.

- d. The posterior head and neck layer-by-layer autopsy included the exposure of the posterior cervical spine and a laminectomy of the posterior spines and laminae of C3 through C7. After study of the scalp the calvarium was opened and the brain and cervical spinal cord removed as a unit for further study.
3. A comparison was made of the relative data producing value of the radiological examination versus a careful, layer-by-layer study of the soft tissues, i.e., muscles, vessels, nerves, etc.
- 3.&4. The CT scan helps in determining injuries. However, it may be redundant in comparison with the layer-by-layer head and neck dissection. The CT scan visualizes the structures in situ and provides a 3-dimensional readout as desired. Preliminary comparisons of video tape recordings of the autopsy as layer-by-layer dissections with the CT scan provided considerable information concerning the relative value of each. Layer-by-layer autopsy dissections and CT scans are complimentary in the information derived, since both techniques will pick up detail that may be missed by one or the other technique. For example, cervical spine manipulations or manipulations of the spinous processes may not be readily picked up in dissections or in the usual radiologic examinations.

Studies utilizing video tape recordings of autopsy layer-by-layer dissections compared with CT scans should provide useful and definitive data.

The use of CT scans has identified several entities which are not fully appreciated pathologically. Although the CT scan is able to detect most lesions, its predictive capabilities have not been fully explored.

The CT scan is a powerful tool which defines the pathology of brain trauma. Qualitative impressions of the prevalence of CT abnormalities and its predictive value in various specific brain lesions are available. Quantitative data concerning these correlations are generally lacking.

Correlations between individual pathological lesions as determined by layer-by-layer autopsy dissections and CT abnormalities are generally good. Correlations are, at this time, less precise for detection of small and unusual lesions.

5. Initially several methods and materials were used in determining the optimum technique of removal of the cervical spine and cord and the replacement of a substitute for the vertebral column to maintain the alignment and integrity of the head, neck, and trunk.

Modification of the autopsy procedure with the elimination of the removal of the cervical vertebral column made cervical vertebral column replacement no longer necessary.

The presently suggested technique of doing a cervical laminectomy and removing the brain, brain stem and cervical spinal cord as a unit does not require the removal of the cervical vertebral column.

6.

PROJECTED TIME FOR PERFORMING

HEAD AND NECK AUTOPSIES AS PROPOSED:

Autopsy Surgeon

Three hours each case; performs general autopsy plus specialized autopsy of head and neck.

Embalmer

One hour each case; performs routine embalment; seals and sutures back of neck.

Darkroom Assistant

One hour each case; times printer, prints, processes, sorts, and files negatives and prints (all color).

Medical Transcriber-Typist

One hour and forty-five minutes each case; transcribes and proofreads dictated autopsy report.

Autopsy Technician-Photographer

Two and one-half hours each case; prepares room; places body on table; assists with autopsy; does all photographing and x-raying; washes and removes body; cleans the autopsy table and environs.

Accounting Technician

One hour each case; sorts employees' time cards; prepares time roll payment; prepares invoices.

Supplies

\$40.00 each case; photographic supplies, x-ray supplies, embalming materials, office supplies, etc.

NOTE:

Overhead for management staff, facility and equipment use, etc., will vary from institution to institution.

MANUAL FOR HEAD AND NECK INJURY ASSESSMENT

The Investigator should inspect the body at the scene of death. A general description should be given by the Investigator, and upon removing the remains, keep all clothing and evidence intact when the body is transported to the Coroner's facilities. All clothing and evidence must be documented.

Preliminary orientation at the Coroner's facility should be made upon receipt of the victim at the facility. This orientation examination should consist of a physical description of the victim with the garments intact.

The Forensic Photographer, as part of the examining team, should photograph for documentation records, the surface, clothing, skin for bruises, contusions, etc.

Photographic documentation should be taken under the direction of a Forensic Pathologist. All photographs taken of parts of the body must be medically oriented and specifically landmarked, i.e., case number, scale, identifying labels such as - right-R, left-L, cranial-Cr., caudal-CA., anterior-A, posterior-P, medial-M, lateral-L., etc.

Simplified diagrams should be used in this documentation for various parts of the head, neck and remainder of the body.

Upon completion of the physical and photographic examination and documentation, the next phase consisting of the Radiological examination should be performed.

This portion of the examination should be done by a well-trained forensic x-ray technician under the supervision of a Forensic Radiologist or Neuroradiologist. The various x-ray oriented views should be taken as outlined in the procedural protocol. X-rays of the cervical spine should be taken in the following manner: antero-posterior, lateral in the hyperflexed, normal and hyper-extended positions, right and left oblique and pillar views. X-ray orientation should include diagrams indicating sites of lesions, etc., and specifically instructing the x-ray technician of orientations assuring better x-rays.

Angiography and/or computerized axial tomography should be included if indicated in the judgment of the Forensic Radiologist.

Computerized Axial Tomography (CAT Scan) examinations should be done only when indicated by the Forensic Radiologist.

Cervical and cranial angiography including subtractive x-ray techniques to visualize the vertebral arteries may be necessary

when routine x-rays such as previously outlined indicate the possibility of cervical vertebrae fractures and/or dislocations. X-ray opaque materials injected into appropriate vessels (subclavian, carotid or vertebral arteries) with x-rays taken before, during and after injection and the subtractive technique employed should visualize vessel lacerations, tears, ruptures with subsequent hemorrhage, etc.

The Forensic Pathologist will perform his examination and autopsy after the Forensic Radiologist has completed his study. Complete examination of the victim is again made and all bruises, markings, etc. charted and recorded. This portion of the examination is physical and external. At this point, the range of motion and flexibility of the cervical spine is determined jointly by the Forensic Pathologist and Forensic Anatomist. All markings and injuries, abrasions, bruises, etc. should be indicated accurately by measurements on standard autopsy charts and data forms.

The general autopsy of the trunk (thorax, abdomen and pelvis) and extremities when indicated should follow the procedure outlined by the Army Method. However, this general autopsy procedure should be modified in that the sternum is transected at the level of the middle of the manubrium sterni and the rib cage removed, leaving the cranial part of the manubrium sterni intact along with the clavicles and first ribs. The structures of the head and neck will therefore remain intact for the step-by-step layer autopsy of the head and neck.

The personnel required as an interdisciplinary team should basically be comprised of the following:

- At-scene Investigator
- Coroner Facility Investigator
- Forensic Photographer
- Forensic Radiologist and/or Neuroradiologist
- Forensically-trained X-ray Technician
- Forensic Anatomist
- Forensic Neuropathologist
- Autopsy Assistant
- Orthopaedic Surgeon (optional)
- Bio-engineer (optional)

HEAD AND NECK INJURY ASSESSMENT PROTOCOL

Specialized Layer-by-Layer Head and Neck Autopsy Dissection

The anterior neck dissection is conducted with the body in supine position. The skin and superficial fascia are removed. The external jugular veins are examined for evidence of lacerations. The sterno-mastoid muscles are next examined for signs of hemorrhage due to hyperextension. The ribbon or strap muscles are next examined followed by the examination of the hyoid, thyroid and cricoid bone and the tracheal cartilage. The thyroid gland and its capsule are next examined. The right and left carotid sheaths, lying deep to the ribbon muscles, are exposed in their entire course and examined for hemorrhage or possible lacerations, etc. The carotid sheaths should be opened and the vagus nerve examined for evidence of laceration or compression. The sympathetic trunk should next be examined deep to the carotid sheath with emphasis on the area of the superior cervical ganglion at the angle of the mandible.

Lateral retraction of the carotid sheath and its contained vessels and vagus nerve on both sides will leave the trachea, thyroid gland, pharynx, larynx and esophagus in the midline for careful examination. The trachea is sectioned as low as feasible (suprasternal notch) and its interior examined. The esophagus is then sectioned at the level of C6 or C7 and its interior also examined. The trachea, esophagus, pharynx and larynx are retracted upward to visualize and examine the longus colli muscles and anterior portion of the cervical vertebral column.

The passage of the two vertebral arteries into the transverse foramina of the sixth cervical vertebrae should be carefully examined. At this stage in the cervical autopsy, the major portion of the anterior vertebral column has been exposed. The area of the posterior triangle and retromandibular region should be examined carefully. The cervical viscera and tongue are now optionally removed; however, the abbreviated procedure in which only the larynx is removed is acceptable. Extensive dissections (removal of cervical viscera) create difficulties for the embalmers when they have to inject preservatives into the body. The removal of the tongue should be optional. This is done at this facility since the question of whether or not epilepsy might be involved can thus be evaluated.

POSTERIOR CERVICAL AUTOPSY

The body is placed in the prone position. The posterior layer-by-layer autopsy can now be done. A longitudinal incision through the skin is made from the external occipital protuberance to the spine of the seventh cervical vertebra (spinous prominens) and the skin reflected laterally. The trapezius, splenius capitis and cervicis and the semispinalis capitis muscles are examined. The short lateral rotators are cleaned and the ligaments and soft tissues examined for lacerations, tears, hemorrhage, etc. The

laminae and spines should be cleaned and carefully examined for fractures and the muscle removal extended laterally to the articular processes to examine the articular facets.

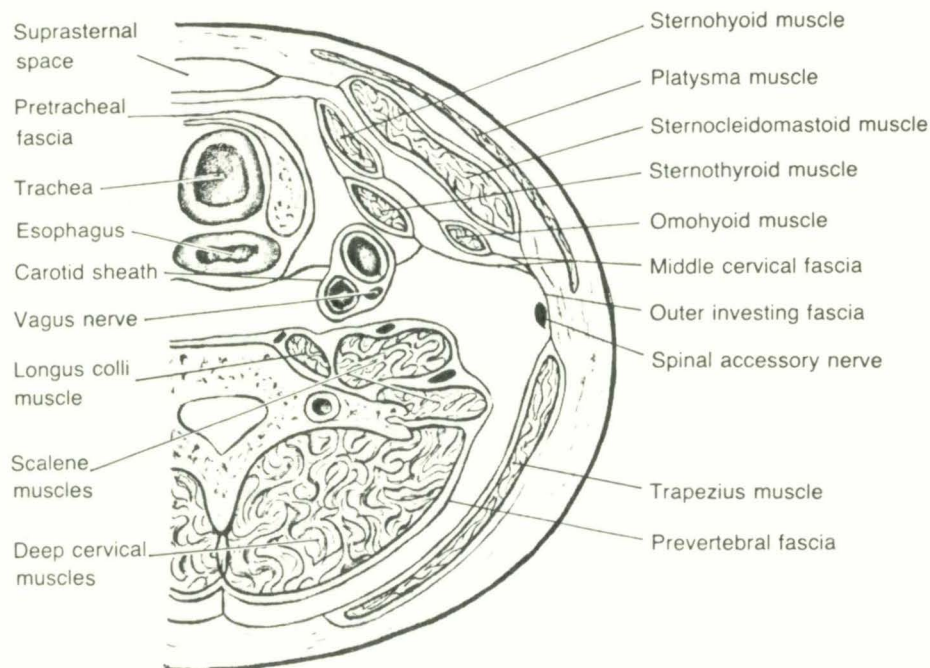
The posterior dissection must include a careful dissection and examination of the suboccipital musculature, nerves and vessels. The removal of the suboccipital muscles will expose the atlas and axis and the atlanto-occipital and atlanto-axial articulations. The mobility of the atlanto-occipital and atlanto-axial joints should be carefully examined and the ligaments checked for tearing, stretching, etc. The lateral processes of the atlas should now be cleaned and the upper course of the vertebral artery examined as it leaves the axis and passes over the upper surface of the atlas into the foramen magnum.

The displacement or shifting, or the antero-posterior dislocation of the atlas and the skull, or the atlas on the axis must be accurately measured. If shifting antero-posteriorly might have occurred then fracture of the odontoid process may be present, or lateral shifting may be due to tearing of the capsule of the atlanto-axial or atlanto-occipital joints with possible injury to the vertebral vessels or the spinal cord.

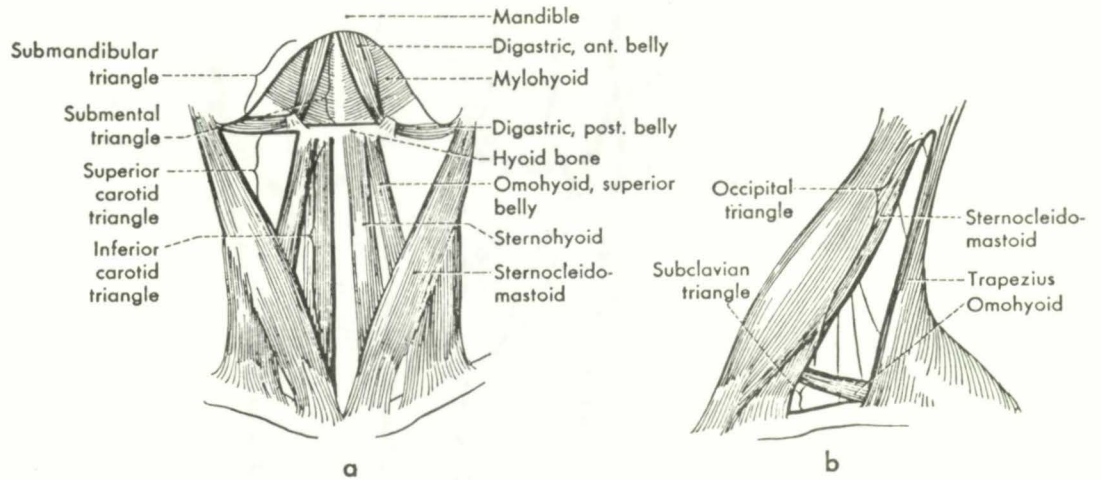
Careful examination of the suboccipital area, the laminae and spinous processes of cervical vertebrae C3 through C7 should be done next.

The following illustrations taken from published sources may be modified for this report and procedure protocol if deemed necessary. The assumption has been made that the forensic pathologist performing this layer by layer head and neck autopsy procedure should be adequately trained and therefore fully knowledgeable concerning the involved anatomy.

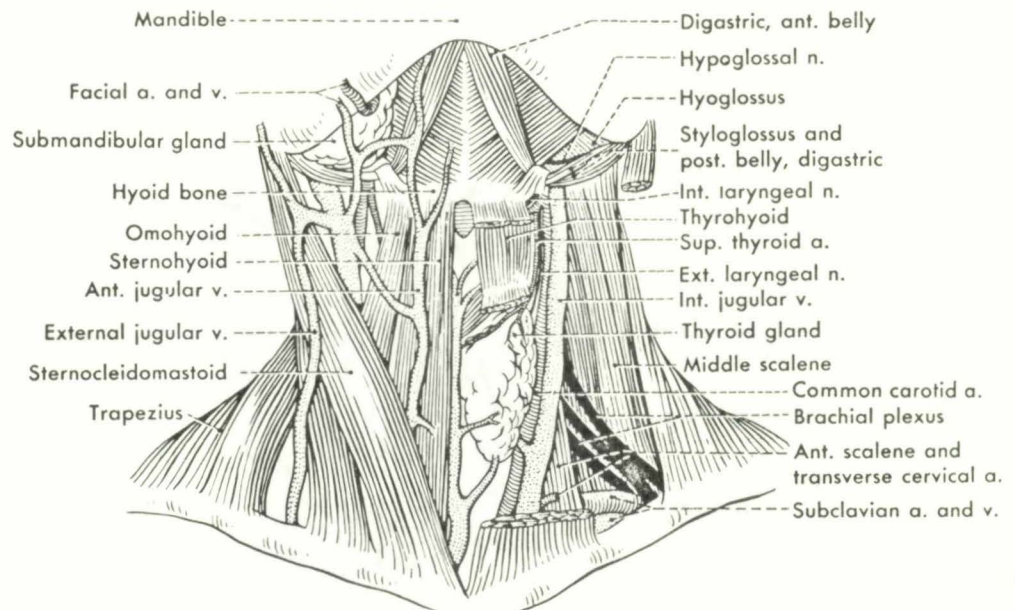
1.



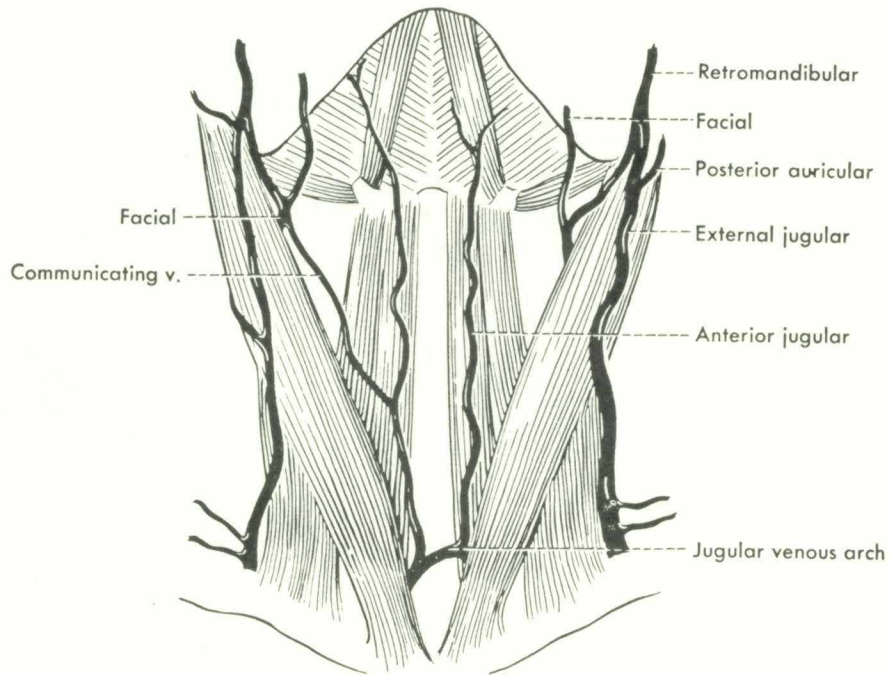
2.



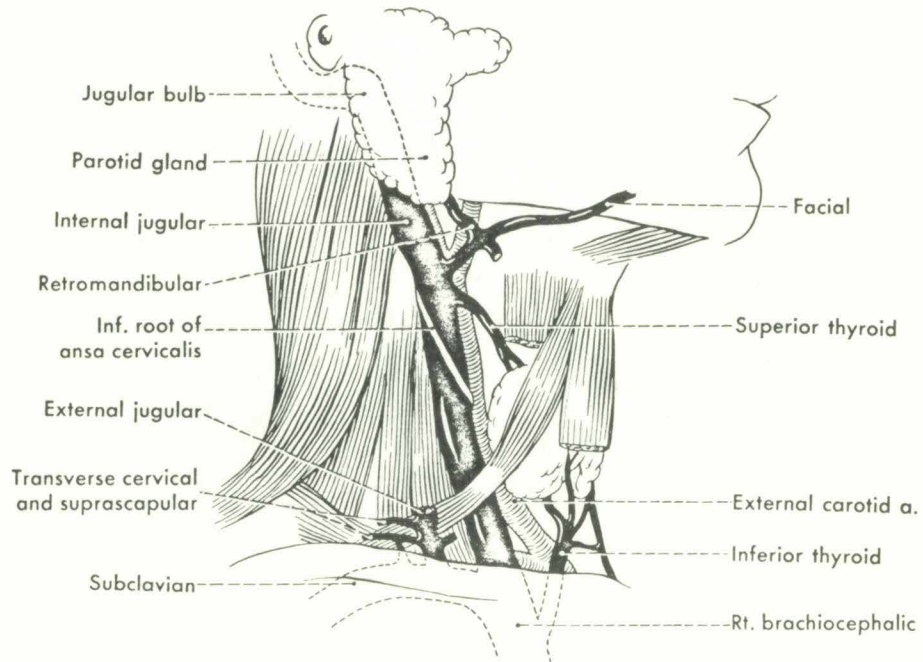
3.



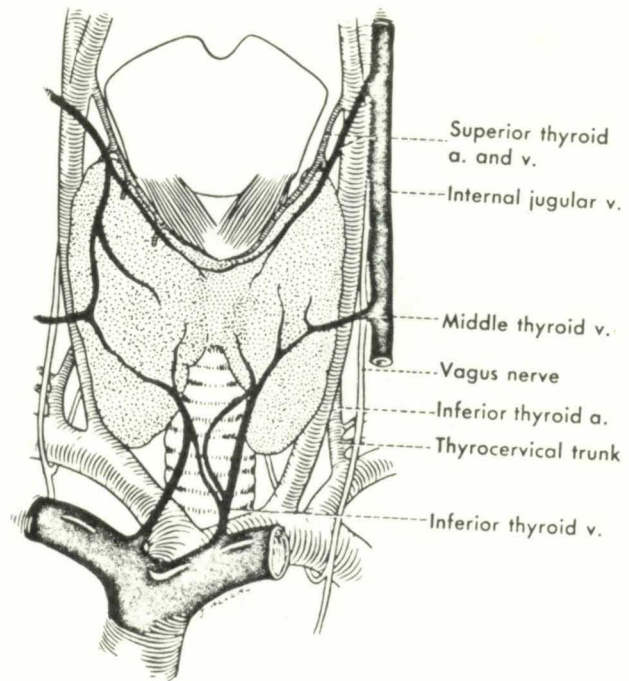
4.



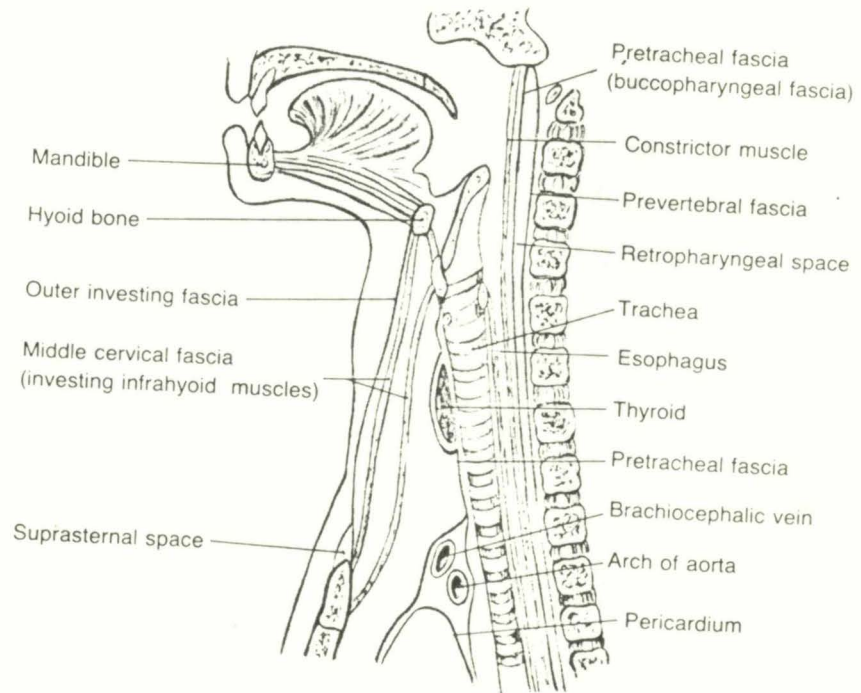
5.



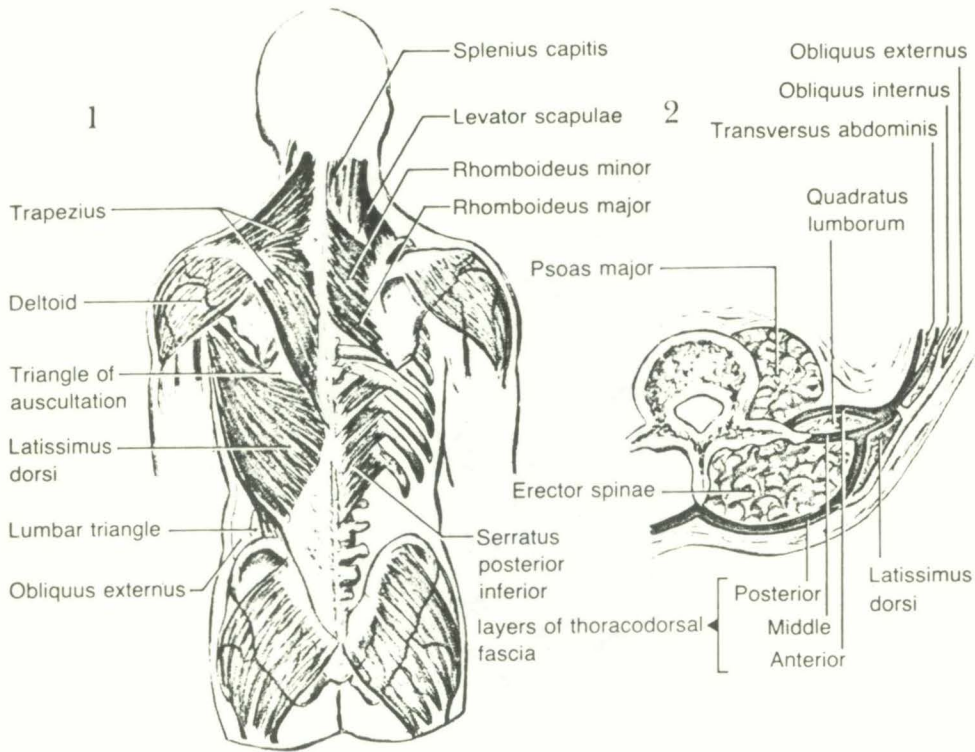
6.



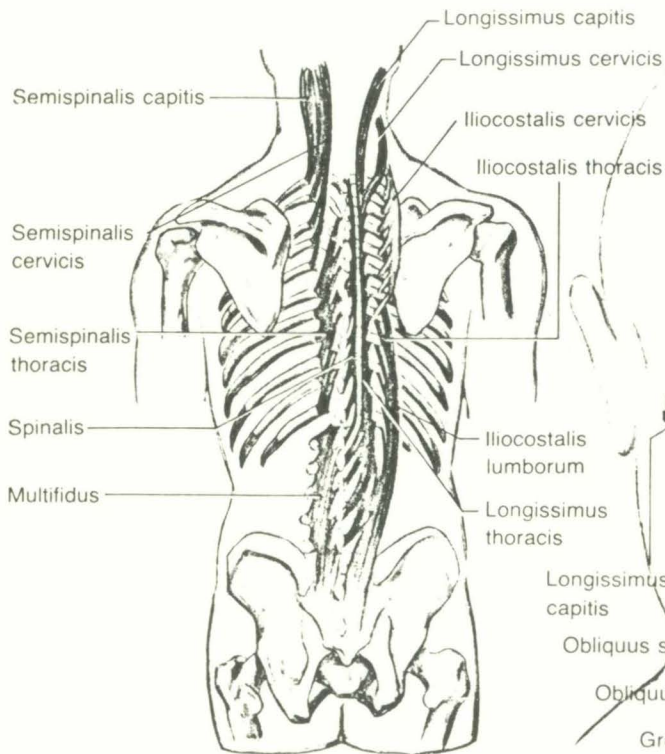
7.



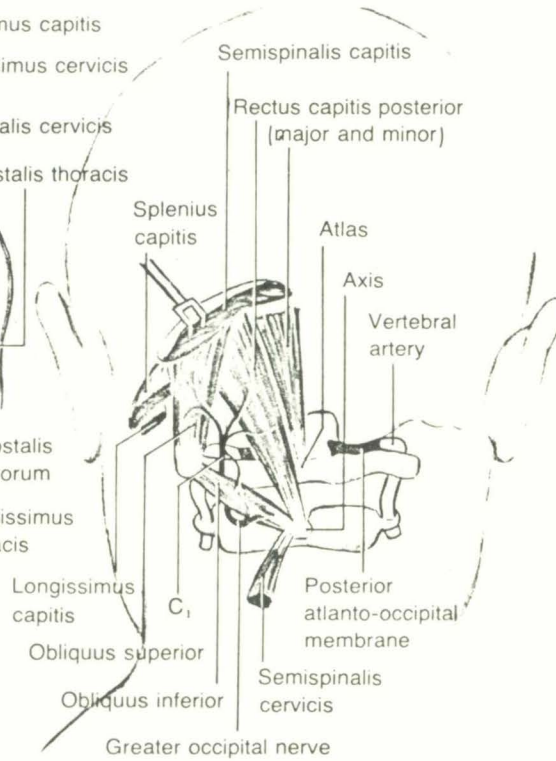
8.



9.



10.



REFERENCES

Pathology

1. Baker, R.D.: Postmortem examination: specific methods and procedures. Philadelphia, Saunders, 1967.
2. Ludwig, J.: Current methods of autopsy practice. Philadelphia, Saunders, 1972.
3. Rezek & Millard: Autopsy pathology. Springfield (Ill), Thomas, 1963.
4. Saphir, O.: Autopsy diagnosis and technic. New York, P.B. Hoeber, 1958.
5. U.S. Department of Defense, Army Department: Autopsy manual. Washington, D.C., U.S. Government Printing Office, 1960.

Anatomy

1. Gardner, Gray and O'Rahilly: Anatomy (4th Ed.) Philadelphia, Saunders, 1975.
2. Healey: Synopsis of clinical anatomy. Philadelphia, Saunders, 1969.
3. Grant, J.C.: Atlas of anatomy (4th Ed.) Baltimore, Williams and Wilkens, 1975.
4. Brantigan: Clinical anatomy. New York, McGraw-Hill, 1963.
5. Rohen and Bergmann: Practical anatomy. Futura Publishing Co., 1973.
6. Lopez-Alvarez: Atlas of anatomy. Philadelphia, Saunders, 1971.

Illustrations

1. Hollinshead, W.H.: Anatomy for surgeons: Volume 1 (2nd Ed.) The head and neck. New York, Harper & Row, 1968.
2. Leeson, C.R. & Leeson, T.S.: Human structure. A companion to anatomical studies. Philadelphia, Saunders, 1972.

HEAD AND NECK INJURY ASSESSMENT PROTOCOL

Examination of the Brain and Spinal Cord

This protocol is primarily intended for the examination of DOA's, but it can also be applied to the examination of survivors of various durations. In the long term survivors (several weeks to months or more), however, the histologic examination plays a far more important role inasmuch as reactive changes are clear-cut and subtle changes can be brought out with differential stains.

Prior to opening of the calvarium for examination of the intracranial contents, ascertain that the following have been done:

1. Skull x-ray series.
2. Cervical spine x-rays.
3. Inspection of the scalp for contusion, hematoma, laceration, and other marks.
4. Cisternal tap for examination of CSF.

The method for removal of the brain and spinal cord in this PROTOCOL differs from the traditional one in that the object is to remove the brain and the cervical spinal cord down to the level of C7 as a single unit. In outline, this requires that the posterior neck dissection had been previously performed down to the vertebral laminae. This is followed by cervical laminectomy including the atlas and axis. The spinal cord is freed to be later pulled up through the foramen magnum from above with the brain. The body is then turned supine and the brain removed in the usual manner.

A. PROCEDURE FOR RELEASE OF THE SPINAL CORD

1. Following the posterior neck dissection, clean away the soft tissues from the spinous processes and laminae down to C7.
2. Before proceeding with a laminectomy, grasp each cervical spinous process with Kocher forceps and attempt to move the vertebra in the anteroposterior direction. If laxity is present, take radiographs of the lateral view of the cervical spine with the mobile vertebra displaced in the anterior and posterior positions as much as the laxity allows with only moderate force.
3. Unroof the spinal canal by performing a laminectomy from C1 through C7 using a Stryker saw. If a blade of large diameter is not available, in order to make the cut through the lateral margin of the laminae, it may be necessary to remove the spinous processes if they are especially tall. Cut the posterior atlanto-occipital membrane between the basiocciput and the atlas and lift away the freed laminae to expose the spinal dura mater. Take care not to destroy the vertebral artery.

4. Look for epidural hematoma, and, if present, record the location and determine the volume by scooping the clots into a 100 ml graduated cylinder containing 50 ml of water. The final volume minus 50 ml will give you the exact volume of the hematoma. Indicate the level with a reference marker and photograph.
5. Examine the dura mater for tears, dural hemorrhage, and underlying discoloration.
6. Making a button-hole in the dura at the highest exposed level, slit the dura over its entire length along the posterior midline, taking care not to dislodge any underlying subdural hematoma. If a hematoma is present, indicate the level with a reference marker and photograph.
7. Transect the spinal cord at C7 and free the cord from the dura by carefully cutting all the dentate ligaments and roots at the root sleeves.
8. After the spinal cord is freed, return the cord to the spinal canal and cover with a wet towel. Holding the towel in place, turn the body over to the supine position for removal of the brain.

B. PROCEDURE FOR REMOVAL OF BRAIN

1. Place a 5" block under the occiput to raise the head to the proper angle.
2. Separate hair over crown of head between the mastoid processes with a comb.
3. Insert a pointed knife through the skin over one mastoid process, with cutting edge facing outward, and proceed toward the crown and down to the other mastoid process, cutting the scalp by lifting up the knife while the tip of the knife rests against the skull, thus avoiding cutting off any hair.
4. Reflect the scalp forward over the forehead up to but not beyond the supraorbital ridge, using a dry towel to hold the scalp margin. Reflect the scalp posteriorly toward the occiput.
5. Before applying the Stryker saw, have a basin ready to place beneath the head to catch any blood which may escape from the epidural space.

6. Remove the calvarium by making a circumferential cut using a Stryker saw. Make "V" shaped notches at the mid-frontal and at both temporal regions so the calvarium will retain its former position when replaced. Care should be taken not to make the anterior cut so low as to show through the forehead. The posterior cut should be low enough to permit delivery of the brain but above the posterior fossa. The cut at the temporal region should be carried to a point about one inch above the base of the pinna. The saw cut should be down to but not penetrating the dura.
7. Pry the calvarium loose by twisting a T-shaped chisel in the saw cut at the forehead or using a chisel and hammer. Place a basin at the occiput to catch any free flowing blood or clot which may escape when the calvarium is pried loose.
8. If present, record the location and measure the volume of epidural hematoma by the same method described under examination of the spinal cord. Start with a 500 ml graduated cylinder containing 100 ml of water. Add the hematoma and the fluids and clots collected in the basin at the time of opening the cranial cavity. Record the total volume minus 100 ml as the epidural hematoma. Photograph, if the clot remains in situ. Usually the hematoma will fall away.
9. If an acute epidural hematoma were present, after cleaning away the hematoma, attempt to identify a point of rupture of the meningeal artery, most commonly beneath the temporal squama.
10. If no epidural hematoma is present, look carefully for the telltale darkening of the dura of underlying acute subdural hematoma. Place a catch basin at the occiput before proceeding with incision of the dura. Incise the dura along the saw cut anteriorly and bilaterally but not posteriorly until you are ready to deliver the brain from the cranial cavity. If an acute subdural hematoma is present, then the incision can be extended posteriorly so the dura can be reflected to expose the hematoma. Try to retain the hematoma in position and photograph. Remove and measure the volume of the hematoma as under Paragraph B8 above. If a hematoma is not present, the dura is not cut posteriorly so as to provide support for the brain while it is being retracted in the process of cutting the blood vessels and cranial nerves.
11. At the most anterior point, cut the falx cerebri down to the crista galli.

12. Deliver the frontal poles using fingers to expose the olfactory bulbs which should be carefully lifted from the olfactory fossae. The now exposed optic nerves are cut as close to the optic canals as possible. The internal carotid arteries will then come into view just beneath the optic nerves. Cut them carefully at right angle. Cut the infundibular stalk. The oculomotor nerves will come into view which should be examined for hemorrhage or bruising. Cut them as long as possible at a point as they enter the wall of the cavernous sinus.
13. Rotate the head to one side and allow the uppermost temporal pole to fall out of the middle fossa. This will expose the petrous ridge of the temporal bone, the tentorium, and the margin of the incisura tentorii. Inspect the tentorium for hemorrhage.
14. Open the posterior fossa by cutting the tentorium cerebelli, beginning from the free margin of the incisura and cutting along the posterior margin of the petrous ridge and laterally and posteriorly just inside the transverse sinus without entering the latter. The cut should be carried as close as possible to the falx posteriorly. Do the same on the opposite side.
15. Straighten the head back to the neutral position and cut in order the following cranial nerves: 5th, 6th, 7th and 8th, 9th, 10th, 11th, and 12th.
16. Identify the vertebral arteries and with scissors carefully cut them just proximal to the takeoff of the posterior inferior cerebellar arteries. Do not make multiple slashes with scalpel.
17. Place fingers on either of the cerebellar tonsils and slowly deliver the cerebellum from the posterior fossa. If free, the spinal cord will come out easily at the same time. If not, the cord will have to be carefully freed by an assistant from below with the body on its side.
18. Inspect the floor of the cranium for hemorrhage. Examine the cerebellar tentorium and sinuses for tears. Peel the dura from the base of the skull and look for fractures.
19. Collect and measure the volume of any fluid or clotted blood in the posterior fossa by the method described under B8.

C. PROTOCOL FOR EXAMINATION OF EXTERNAL PARTS

1. Inspect the external and internal surfaces of the dura for residual hemorrhage, tears, puncture sites, rupture of meningeal arteries, pus, etc. and record the involved sites and extent. A magnifying lens is helpful.
2. Remove the dura from the brain by cutting the bridging veins and gently retracting the dura from the arachnoid attachments. Cut the posterior falcial attachment near the pineal gland. Look for parafalcial hemorrhage.
3. Weigh the fresh brain together with the attached cervical spinal cord.
4. Describe the leptomeninges (translucent, opaque, etc.), and look for subarachnoid hemorrhages describing their locations and estimated amount.
5. Examine the cerebral hemispheres from the dorsal aspect and make a note of the presence or absence of the following features:
 - a. asymmetry of the hemispheres, if any, or other distortions.
 - b. swelling indicated by the degree of fullness of the gyri and narrowing of sulci. Note any asymmetrical swelling.
 - c. cortical petechiae, contusions, lacerations, focal softening, or chronic lesions such as infarcts or atrophy. Areas likely to show contusions are the frontal and occipital poles, temporal tips, and along the anterior Sylvian fissure.
6. Turn the brain over to examine the ventral aspect of the cerebral hemispheres and the exposed surfaces of the brain stem and cerebellum. Follow the same instructions under B8. Contusions are most likely to be seen involving the rectus and orbital frontal gyri.
7. Identify the major arteries* at the base and mention the presence or absence of the following:
 - a. anomalies, including aneurysm
 - b. displacement (including stretching)
 - c. atherosclerosis

d. occlusion

e. rupture

*internal carotid, posterior communicating, anterior cerebral, anterior communicating, horizontal portion of middle cerebral; vertebral, posterior inferior cerebellar, anterior spinal, anterior inferior cerebellar, superior cerebellar, posterior cerebral.

8. Identify the cranial nerves in order and describe them as to their presence or absence, bruising of especially the first three, and their condition otherwise.
9. Note the condition of the external surfaces of the cerebral peduncles, pons, medulla, spinal cord, and cerebellum.
10. Record the presence or absence of the following herniations:
 - a. subfalcial (cingulate)
 - b. uncal-parahippocampal
 - c. sphenoid ridge
 - d. tonsillar

D. FIXATION OF BRAIN

1. Fixative consists of 10% formalin stored over excess calcium carbonate (marble chips).
2. In a container with 2 gallons of 10% formalin, suspend the brain by a string passed under the basilar artery such that no part contacts the container. Fix the string to the container mouth by tapes.
3. Completely replace the fixative with fresh formalin of the same volume in 24 hours.
4. Fix for 10-14 days before cutting.

E. PROTOCOL FOR DISSECTION OF FIXED BRAIN

Before sectioning, gross external abnormalities not previously photographed should be done at this time.

Examination of Internal Parts

In those cases where CT-scans were performed, the cerebrum and brain stem will be cut in the same plane as the CT-scan, which is tilted approximately 15 - 20 degrees from a plane through the frontal and occipital poles to one which passes from the frontal pole through the cerebellum. Other brains will be cut in the usual manner which is at right angles to an axis passing through the frontal and occipital poles. In the brains which are cut along the CT-scan plane, the brain stem is not to be detached from the cerebrum. Weigh the brain with the attached spinal cord.

1. Separate the brain from the spinal cord by a transverse section through the cervicomedullary junction (just above the C1 root or decussation of the pyramids).
2. Take a section from the spinal cord side and label as "CM" for cervicomedullary junction.
3. Weigh the brain.
4. In those brains to be cut coronally, first detach the brain stem and cerebellum from the cerebrum by transecting the midbrain through the cerebral peduncles just above the rostral border of the pons by a straight side to side cut with a scalpel. Do not make the mistake of cutting to the midline from each side.
5. Take a flat 3-4 mm thick section of midbrain from the rostral surface. This section should be taken with utmost care since there is no second chance.
6. Using a cutting board with a glass fence, make coronal sections of the cerebral hemispheres, cutting from the ventral aspect and moving from frontal to occipital pole at approximately 1 cm intervals, each time placing the cut surface against the fence for control. After the first section, there should be no problem in maintaining symmetrical sections of the two hemispheres. In order to have relatively standard coronal sections from case to case, plan to make cuts at the following levels:
 - a. halfway between frontal and temporal poles
 - b. at the temporal tips
 - c. at the optic chiasm
 - d. through the mammillary bodies
 - e. through the substantia nigra
 - f. at the splenium of the corpus callosum

7. Coronal sections are laid out in order with the right hemisphere to the examiner's right side as though he were looking at his own brain from behind.
8. After recording the pathologic findings, weigh each cerebral hemisphere separately. Where hemispheres are attached, separate them by cutting the corpus callosum and other crossing and midline structures at the exact midline.
9. For sections to be made in the plane of the CT-scan, place the brain on its dorsal surface and so placed that the frontal-occipital line is tilted 15-20 degrees from the horizontal with the occipital pole down nearer the table. The initial cut is crucial and should be about 3 cm thick. For symmetry, it is important to keep the interhemispheric fissure vertical to the cutting surface. The knife cut should be carried in a frontal to occipital direction with the knife always parallel to the cutting surface. After the first cut, the subsequent cuts are made at 1 cm intervals with the cut surface flat against the table.
10. After recording the pathologic findings, weigh the hemispheres as in P8 above. The caudal brain stem and cerebellum will separate easily from the cerebral hemispheres; however, at a rostral level, it will be necessary to cut the superior cerebellar peduncles to remove the cerebellum.
11. Systematically identify and inspect the sections for the following anatomic areas and pathologic changes listed in the two columns below: Measure the size of all lesions.

Ventricles	Hematoma
Cortical ribbon	Laceration
Central white matter	Contusion
Optic tract	Edema
Basal ganglia	Petechiae
Thalamus	Anemic and
Hypothalamus	hemorrhagic softening
Corpus callosum	Cyst
Internal capsule	Others
Hippocampal formation	
Subthalamic body	
Red nucleus	
Substantia nigra	
Optic radiation	

12. The brain stem and cerebellum are cut together at right angle to the long axis at 0.5 cm intervals. Identify each cervical spinal cord level by the roots and make transverse sections at each level. Inspect in order the following areas:

Tectum of midbrain
Periaqueductal gray
Region of oculomotor nucleus
Red nucleus
Lateral tegmentum of the midbrain
Substantia nigra
Cerebral peduncle
Rostral pontine tegmentum)
Midpontine tegmentum) Medial and lateral of each
Caudal pontine tegmentum) level
Brachium conjunctivum
Brachium pontis
Medial lemniscus
Basis pontis
Rostral medulla)
Mid-medulla) Medial and lateral of each level
Caudal medulla)
Restiform body
Vestibular region
Region of reticular formation
Region of dorsal nucleus of the vagus
Inferior olives
Pyramids
Regions of nuclei gracilis and cuneatus
Decussation of the pyramids
Posterior columns)
Posterior gray horns)
Anterior gray horns) at each level
Anterolateral funiculus)

13. Horizontally sectioned cerebellum is inspected and lesions classified as closely as possible to the following anatomic areas:

Anterior vermis
Posterior vermis
Medial and lateral superior cerebellum hemisphere
Medial and lateral inferior cerebellar hemisphere

F. PROTOCOL FOR TAKING BLOCKS FOR MICROSCOPIC SECTIONS

Blocks are to be taken of sufficient size so as to permit easy anatomic localization; but, at the same time, it should be small enough to fit under a 24 x 50 mm cover glass to fit on a 1 x 3" slide. There is no problem in identifying the origin

of sections from the deep nuclei, but small sections of cerebral cortex without some external surface contour makes identification difficult and dependent upon knowledge of cytoarchitectonics. In order to make a complete statement of such areas as the basal ganglia and thalamus, it is important not to cut through them.

For the purpose of this study, blocks from the areas listed below will be considered routine, and they will be taken in every case. Of course, where gross lesions occur outside these areas, blocks from these areas will be submitted as additional blocks. Routine blocks are to be taken from homologous areas on each side. As a convention, the blocks from the right side will be notched with a "V" along one margin.

- Frontal pole
- Orbital frontal and rectus gyri
- Occipital pole
- Amygdaloid complex
- Lenticular nucleus (anterior)
- Thalamus at the level of subthalamic nucleus
- Hippocampal formation with parahippocampal, fusiform,
and inferior temporal gyri
- Hypothalamus
 - a. Anterior level
 - b. Mammillary bodies
- Midbrain
- Rostral pons
- Mid-pons
- Mid-medulla
- Caudal medulla
- Pituitary gland (horizontal section)
- Cerebellar vermis
- Cerebellar tonsil
- C1 spinal cord
- C2
- C3
- C4
- C5
- C6
- C7

A total of 33 routine sections.

DIAGNOSTIC CATEGORIES OF ACUTE INTRACRANIAL AND SPINAL LESIONS

I. Primary Surface Lesions

A. Hemorrhage, external

1. Hematoma, epidural + locator + volume
2. Hematoma, subdural + locator + volume

B. Surface of brain

1. Subarachnoid

- a. Diffuse + locator
- b. Hematoma + locator + volume

C. Contusions + locator

D. Laceration + locator + size

E. Rupture of blood vessels + locator

F. Avulsion of cranial nerve + locator

II. Primary Internal Lesions

A. Hemorrhage

1. Hematoma, intracerebral + locator + size
2. Contusion + locator + size
3. Petechiae + locator
4. Intraventricular + volume

B. Infarction

1. Hemorrhagic + locator
2. Anemia + locator

C. Edema

1. Unilateral, by weight of hemisphere when that hemisphere exceeds the weight of the other by more than 50 gm
2. Diffuse, by weight of both hemispheres when they weigh in excess of 1350 gm after subtraction of parenchymal hematoma, if any

III. Secondary Lesions

A. Herniations

1. Cingulate
2. Orbitofrontal (lesser wing of sphenoid)
3. Uncal-parahippocampal
4. Central (diencephalic and midbrain)
5. Superior cerebellar (upward)
6. Cerebellar tonsillar

B. Kernohan-Woltman notch

C. Compression of midbrain (side to side)

D. Infarcts secondary to vascular compression + locators

HEAD AND NECK INJURY ASSESSMENT PROTOCOL

Radiologic Examination of the Head and Neck

The biomechanical prevention of trauma is first dependent upon the accurate identification of significant injuries. The prime indicators for head and neck injury are identified clinically, radiologically, and pathologically. Radiologically identifiable indicators for head and neck injuries may be found in the soft tissues, bone, brain, spinal cord, and blood vessels. These radiologic findings may be correlated with subsequent pathologic findings so that some assessment of the overall severity of injuries may be accomplished. These correlations are easily established in those subjects whose final outcome has been death. All findings may be subjected to computer storage and analysis.

The radiologic assessment of head and neck injuries includes the use of plain x-rays, myelography, arteriography, and computerized tomography. All of these examinations require a neuroradiologist and a well trained radiologic technologist to obtain the most information with the least expenditure of time and materials. The equipment necessary for this type of examination is too costly for purely investigative research. Hence the examination can only be conducted in a highly equipped radiology department.

Materials and Methods:

The plain x-ray examinations of the head and neck will include a standard series of films:

1. The skull series will include a straight AP, lateral and half axial projection. Additional projections may be obtained at the discretion of the radiologist.
2. The cervical spine series will include as a minimum: an AP, lateral, "Pillars", and odontoid views. Additional views may again be obtained by the radiologist.

Optional:

Computerized tomography of the head and neck will be performed by the radiologist prior to the administration of contrast material. The CT (computerized tomography) sections will be obtained at intervals of 1 cm or less. The accumulated data will be stored on disc or tape for subsequent reevaluation. A series of these sections will be recorded on film for immediate documentation of the findings.

A cisternal puncture will be performed to examine the cerebrospinal fluid for evidence of subarachnoid hemorrhage. Water soluble iodinated contrast material will be injected through the cisternal puncture needle after the CSF specimen has been obtained.

A second CT scan will be obtained to further evaluate areas of the brain and spinal cord which are best demonstrated after opacification of the subarachnoid space.

An AP and lateral view of the skull and cervical spine will be obtained to identify any myelographic injury patterns.

A vertebral arteriogram will be performed in the lateral projection using water soluble iodinated contrast material. It is important that the computerized tomography be performed prior to the arteriogram because the contrast material will diffuse into the brain tissue from the small vessels and may obscure the true anatomy and density.

The radiographic examinations will be evaluated and a preliminary report made. A dictated report of each subject will be submitted for computer storage and analysis.

REFERENCES

A. Cervical Spine Examination in Trauma

1. Jefferson, G.: Fracture of Atlas vertebra, report of four cases, and review of those previously recorded. Br J Surg, 1920, 7:407-422.
2. Jefferson, G.: Remarks on Fractures of first cervical vertebra. Br Med J, 1927, 21:153-157.
3. Gabrielson, T.O. and Maxwell, J.A.: Traumatic atlanto-occipital dislocation with case report of a patient who survived. Am J Roentgenol, 97-3, pp 624-629.
4. Shrago, G.G.: Cervical spine injuries. Association with head trauma. A review of fifty patients. Am J Roentgenol, 118, No. 3, July, 1973, pp 670-673.
5. Whitley, J.E. and Forsyth, H.F.: Classification of cervical spine injuries. Am J Roentgenol, 1960, 83, pp 633-644.

B. "Pillars View"

1. Smith, G.R., Beckley, D.E., Abel, M.S.: Articular mass fracture. A neglected cause of post-traumatic neck pain? Clin Radiol, 1976, 27:335-340.
2. Vines, F.S.: The significance of "Occult" fractures of the cervical spine. Am J Roentgenol, 1969, 107:3:493-504.

3. Weir, D.C.: Roentgen Diagnosis of Injuries of the Cervical Spine. Refresher Course at the Annual Meeting of the Radiological Society of North America. Chicago, 1968.

C. Subarachnoid Contrast Material in CT Scanning

1. Drayer, et al: Computed Tomographic Diagnosis of Suprasellar masses by Intrathecal Enhancement. Radiology, 123:339-344, May, 1977.
2. Wylie, I.G. et al: Results of the use of a new water soluble contrast medium (Metrizamide) in the posterior fossa of the baboon. Br J Radiol, 48:1007-1010, 1975.
3. Greitz, T. et al: Computer Assisted Tomography of intracranial CSF circulation using a water soluble contrast medium. Acta Radiol (Diagn), 15:497-507, 1974.
4. Sackett, J.F. et al: Metrizamide - CSF Contrast Medium. Radiology, 123:779-782, June, 1977.

NOTE: Special forms utilized in Radiologic Examination of the Head and Neck follow.

CERVICAL SPINE

PATIENT: _____

HOSP. NO: _____

LEVELS: _____

VIEWS: _____

FINDINGS:

ALIGNMENT

ANATOMIC AREA

NORMAL

SUBLUXATION

DISLOCATION

FRACTURES

LOCATION

BODIES

ARTICULAR FACETS

LATERAL MASS

SPINOUS PROCESS

LAMINA

OCCIPUT

CONGENITAL ANOMALIES

TYPE & LOCATION

DEGENERATIVE CHANGES

TYPE & LOCATION

DISC SPACES

MISCELLANEOUS FINDINGS

MYELOGRAM

+

PUNCTURE LEVEL

CONTRAST MATERIAL

TYPE & AMOUNT

CHARACTER OF CSF

FINDINGS

LOCATION

EXTRADURAL LESIONS

INTRADURAL LESIONS

EXTRAMEDULLARY LESIONS

INTRAMEDULLARY LESIONS

SKULL SERIES

VIEWS:

FINDINGS:

ABNORMALITIES
CONGENITAL FRACTURES
MISCELLANEOUS

CALVARIUM

VAULT

BASE

FACIAL BONES & SINUSES

SELLA TURCICA

CALCIFICATIONS (INCLUDING PINEAL)

ABNORMAL AIR COLLECTION

ANGIOGRAM

TYPE

CONTRAST

METHOD

VIEWS

FINDINGS

EXTRAVASATION

ARTERIAL RAPHE OR LACERATION

DISPLACEMENTS

OCCLUSIONS

