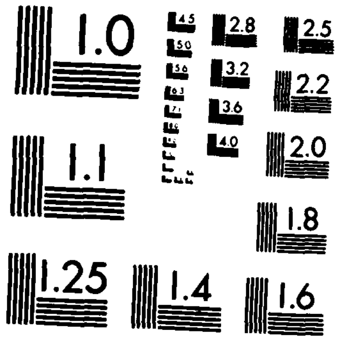
AD-A129 745 SPINAL INJURY STUDIES IN THE HUMAN CADAVER(U) MEDICAL COLL OF WISCONSIN MILWAUKEE A SANCES ET AL. 1983 N00014-77-C-0749 1/1

UNCLASSIFIED F/G 6/19 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Developments in Mechanics
(Proc 18th Midwestern Mechanics Conf,
Iowa City) 12:377-380, 1983.

SPINAL INJURY STUDIES IN THE HUMAN CADAVER

N00014-77 C-0749

Anthony Sances, Jr., Joel Myklebust, Dennis Maiman, and Sanford Larson
The Medical College of Wisconsin and Marquette University
8700 West Wisconsin Avenue, Milwaukee, WI

Introduction—Injuries produced by compression or tension loads delivered either axially or in association with flexion or extension represent the majority of spinal injuries observed in most centers. The spinal cord routinely is injured by ligament failure, or dislocation, with attendant impact to the spinal cord with bone or disk. While a rich literature exists detailing the retrospective evaluation and injury force vectors associated with spinal injury, few quantitative studies are available.[1,2,3] The costs of medical treatment for all spinal cord injury is estimated to be in excess of 380 million dollars per year. There are approximately 10,000 new cases of acute spinal cord injury each year in the United States.[4] The National Electronics Injury Survey System (NEISS) indicates there are 3,000 new cases of spinal injury due to falls, 3,000 attributed to vehicular accidents, and 4,000 due to other causes each year.

The teaching institutions of the Medical College of Wisconsin including Milwaukee County Medical Complex and Froedtert Memorial Lutheran Hospital are the primary trauma centers for Southeastern Wisconsin. They provide care for over 350 patients with head injuries annually. Between 1975 and 1980 152 cervical spine injury patients and 105 patients with thoracolumbar trauma were treated. Approximately 50% of the patients represented by these statistics were motor vehicle related.[5,6]

This presentation will provide a review of typical clinical findings observed in our institution with a comparison of studies conducted on 50 unembalmed human male cadaver specimens studied with forces applied in compression and transverse to the cervical or thoracolumbar columns. Briefly all specimens were determined to be within normal limits by medical history and x-ray examinations conducted prior to the test. All tissues were x-rayed following each test. Spinal injury was determined by careful gross dissection and confirmation by clinical staff members.

Isolated cervical and thoracolumbar spinal columns were studied. Supporting tissues were carefully removed to avoid damage to the ligaments. Studies conducted in the intact cadaver were done in preparations where the tissues were kept at 2° C. until studied within 1-3 days following death. The loads were applied to the human spinal columns with a Series 810 Materials Test System or a specially designed MTS Servo Control Test Device with a 25 cm piston stroke capable of moving under programmed control at rates up to 10 meters per second. Compression studies with the cervical column aligned axially, or in 30 degrees of flexion or 30 degrees of extension showed a mean failure load in axial compression of approximately 6,000 Newtons (N) with a mean input energy of 137 joules (J). Flexion failure occured with an average of 2000 N and a mean energy of 68 J, and extension failure with a mean of 2200 N with an average energy of 99 J.

Studies with preflexed isolated thoracolumbar and cervical through lumbar segments of the human cadaver with vertical loading demonstrated that the isolated thoracolumbar spines failed with compression loads from approximately 800 to 5100 N. Two specimens, which included the cervical spine, failed between 550 and 800 N. With vertical forces applied to the upper thoracic region of intact seated cadavers, thoracolumbar fractures were observed with forces of 1550 to 2800 N. The forces for fracture were a function of the degree of initial flexion and the length of the spines. All fractures occurred at the low thoracolumbar areas. However, upper thoracic injuries were observed when the cervical elements were included. A free body diagram of the relevant forces and distances for externally applied force to the intact cadaver is given (Fig. 1). For 445 N applied to the thoracocervical junction and typical anatomical data, the force on the ligaments (F_L) is approximately 2000 N, and the force on the vertebral body (F_V) is approximately 2900 N.

Discussion--Studies on the cervical column indicate that more force is required to produce bony or ligamentous damage in the cervical column when the specimens failed with an axial compression in contrast to flexion or extension failures. Axial and flexion failures involved vertebral body compression or fracture with attendant ligament failure. Extension failures routinely involve failure of the anterior ligament complex, and some with avulsion of the vertebral body. Studies of the thoracolumbar sections indicate that the preflexed column or preflexed seated cadavers sustain lower thoracolumbar vertebral fractures which are attendant with posterior ligamentous disruption. It is important to note that in the living subject, significant muscle force can be exerted to protect the posterior ligaments if muscles are pretensioned or have sufficient time to allow for reflex response. Studies conducted with single thoracolumbar vertebral bodies in compression done in our laboratory were within the failure range given by Kazarian and Lin and Liu.[7,8]

ACKNOWLEDGMENT

This research was supported in part by the Office of Naval Research Contract #N00014-77-C-0749.

REFERENCES

1. Sances A Jr, Myklebust JB, Larson SJ, et al: Bioengineering analysis of head and spine injuries, CRC Crit Rev Bioeng 5(2):79-122, 1981.
2. Liu YK: Biomechanics and biophysics of CNS trauma, in Central Nervous System Trauma Research Status Report, G.L. Odom (ed), Duke University, Durham, NC, 1979, p. 36.
3. Sances A Jr, Myklebust J, Houterman C, et al: Head and spine injuries, AGARD Conf Proc No. 322 on Impact Injury Caused by Linear Acceleration: Mechanism, Prevention and Cost, Koln, Germany, April 26-29, 1982, pp. 16-1 - 16-11.
4. Anderson DW, McLaurin RL (eds): Report on the national head and spinal cord injury survey, J Neurosurg 53:1, 1980.
5. Sances A Jr, Myklebust JB, Maiman DJ, et al: The biomechanics of spinal injuries, CRC Crit Rev Bioeng, In Press.
6. Sances A Jr, Maiman DJ, Myklebust JB, et al: Biodynamics of vehicular injuries, in Automotive Engineering and Litigation, Garland Publishing, Inc., In Press.
7. Kazarian L, Graves GA: Compressive strength characteristics of the human vertebral centrum, Spine 2(1):1-14, 1977.
8. Lin HS, Liu YK, Adams KH: Mechanical response of the lumbar intervertebral joint under physiological (complex) loading, J Bone Joint Surg 60A (1):41-55, 1978.

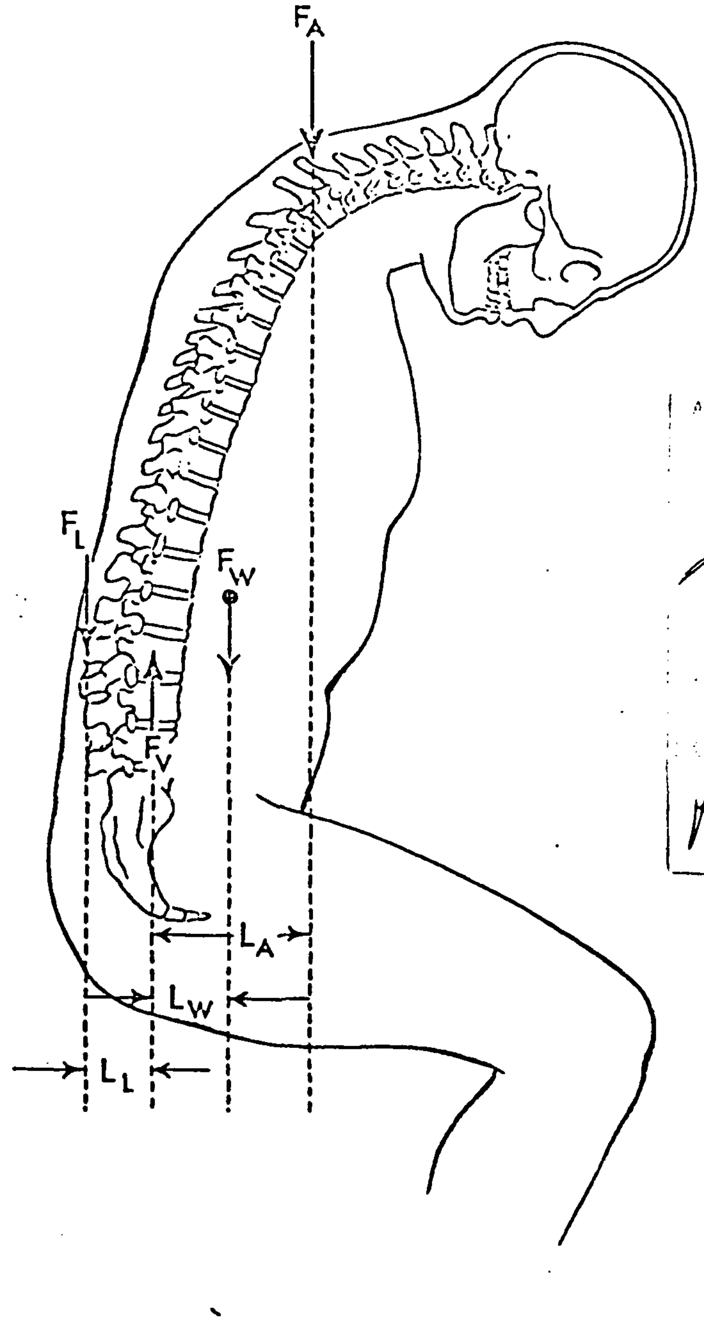


Figure 1 : Schematic illustration of relevant forces and distances for externally applied force (F_A) to produce thoracolumbar injury, F_L = force in posterior ligaments, F_W = weight of upper body acting at center of gravity, F_V = force on vertebral body, L_L, L_W, L_A are corresponding distances from point of rotation about vertebral body to line of action of force where F_W = 45 kg, L_L = 5 cm, L_W = 7.5 cm, L_A = 15 cm.

END

FILMED

8-83

DTIC