

Case Study

Cervical HIVD Probably Related to Long-Term Repetitive Shock and Neck Flexion among Dump-Truck Drivers

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Professional drivers are exposed to whole body vibration, which is a documented risk factor for low back pain¹. Some drivers are exposed to a greater whole body vibration or even shock due to different vehicles or driving conditions². It was only ten years ago that lumbar herniated intervertebral disc (HIVD) was recognized as an occupational disease in Germany, and vertical vibration of the driver is one of the responsible factors³. However, vertical vibration may not be applicable to cervical HIVD, which is generally considered to be due to either degenerative change or accidental injury. In this report, we present two truck drivers, with no known neck injury history, but with long-term exposure to repetitive shock during the earth unloading process, who developed cervical HIVD raising the concern of the possibility of occupational causation.

Case Reports

Case 1

A 50-yr-old male truck driver working more than 20 yr began feeling numbness of the right hand at 36 yr of age, which was followed by left hand numbness. These symptoms worsened about 3 yr ago when bilateral weakness of hands and neck pain developed. Upon physical examination, the clinical data showed hand numbness over C7–8 dermatome, especially the left hand side, mild limping gait on walking, but no definite

weakness. Radiculopathy was diagnosed and consequently he received laminectomy over C3–C7 with C4–C6 fixation. Unfortunately, the minor hand numbness and neck discomfort persisted. The final diagnosis was cervical HIVD with myelopathy s/p operation. Case 1 had been involved in a truck accident 10 yr ago which caused leg injury but did not affect the spine.

Case 2

A 48-yr-old male truck driver working more than 20 yr began to suffer from bilateral numbness of the hands at 34 years of age and C4–C5 HIVD was diagnosed at that time. About 3 yr ago the symptoms became aggravated and he received laminectomy and the pathological report showed degenerative fibrocartilage. The symptoms persisted after operation, with numbness and weakness of both hands and the left lower extremity. Physical examination later revealed a sensory defect with parenthesis over bilateral C5–C8. Follow-up roengenography and MRI showed C2–C3 HIVD with C5 spinal cord compression. Left lumbosacral radiculopathy also was noted in an EMG study. Chronic hepatitis and gout were also noted as past medical history. Both cases denied past medical history and family history of hereditary diseases, such as spinal cord disease. There were no other causes such as injury or tumor, infection etc, and we concluded that the two cases were cervical HIVD due to chronic degeneration.

The two cases shared a similar work experience, driving 12 h a day, 6–7 d a week on unlevelled road. In addition to transporting earth, sand, or stone, the truck was also used for dumping pitch garbage or clay. The truck was 13 tons when empty, with a restriction of 20 tons fully loaded. However, the truck was usually loaded up to 30 or 40 tons in total weight, and the driver often dumped 40–60 runs of load a day in the period 1980 to 1990. To simulate and evaluate the occupational hazard, we launched a worksite evaluation using a biometrics-compatible data logger, an electrical goniometer (Biometrics, SG110, UK), and two 20-g tri-axis accelerometers (Analog devices, ADXL150EM-3, USA; ± 10 g) for physical measurement⁴. The driver was tested with one end of the goniometer attached to C3 of his posterior neck and the other to T1, and with the accelerometers attached to the occipital and C7. The accelerometer located at the occipital was fixed to a cap worn by the subject with an elastic belt to constrict its position on the head. The accelerometer attached to C7 was firmly attached to the subject's neck using double-side tape and surgical tape (3M, Micropore, USA). All accelerometers were adjusted to have their y-axis in the direction of the spinal axis. As shown in the picture of Fig. 1, there was a sharp rise of the truck head around 88 cm above the ground while holding on for the completion

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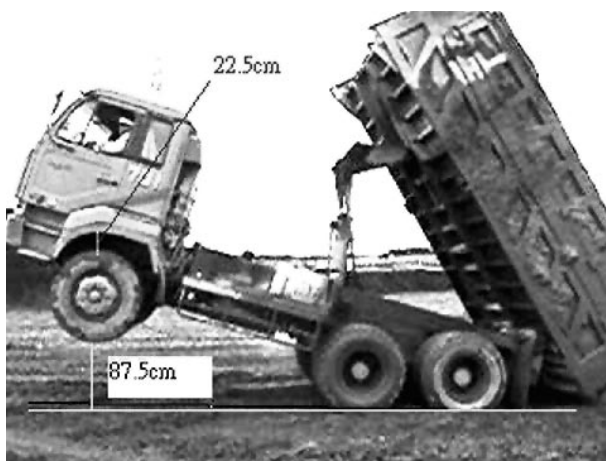


Fig. 1. The elevated and suspended truck head while unloading earth.

of dumping and it suddenly fell down after the earth was unloaded. There was a violent vertical swinging of the drivers' neck in addition to some neck deviation while looking at the rear mirror to monitor the process. The workers suffer a bump-down force when the unloading ends. On-site measurement showed that the shock could produce up to 9 G over the driver's head, neck and shoulder during this process (Table 1). Besides, the induced maximum neck flexion was around 20 degrees (Fig. 2). After the unloading of the earth, the head (or trunk) was propelled forward with continual up and down swing and shock for about 2–3 s after the major impact (Fig. 3).

Discussion

The drivers began experiencing radicular pain seven to ten years after starting work in their occupation. At about 34 and 36 years of age, the symptoms progressed and cervical-HIVD was diagnosed at 45 and 47 years of age, respectively. This is generally younger than other cervical-HIVD cases and raised the first suspicion of occupational causation⁵. A review of the literature showed there are no national standards other than the German one proclaiming the occupational disease standards of HIVD. However, several studies have addressed the causal relationship of low back pain (including lumbar HIVD) with occupational exposure to

vibration, as reviewed by NIOSH, USA¹. The German standard is for the lumbar spine and occupational causation only. In addition to the German legislation addressing HIVD related to whole body vibration, there are studies addressing the possible relation between driving and cervical HIVD. In Connecticut, a case-referent study, was performed including 52 male and 36 female patients with prolapsed cervical HIVD, aged 20–46 yr and two control groups of people without a history suggesting a prolapsed disc, and the results showed positive associations (but of borderline statistical significance) with operating or driving vibrating equipment and with time spent in motor vehicles⁶. Another Danish cohort study, specifically designed to elaborate the risk of cervical HIVD during nearly one million person-years of follow-up⁷ showed the driving professions poses a higher than average risk of cervical HIVD (standard hospitalization rate =142, 95% CI= 126.8–159.6). However, these studies had no exposure measurements available.

The early onset of symptoms and the unique workplace hazard drew our attention to the occupational exposure of our two cases during the dumping process. The measurement results showed vertical and overall vibration of 6.0 and 9.5 G around the neck region. Assuming the weight of a head is about 5.6 kg (8% of 70 kg body weight), the instant shock produced over the head and neck may be up to 494 Newtons (9 G × 5.6 kg × 9.8 m/sec²/G). How much shock can the human spine tolerate? One study reported lumbar spine prosthesis was tested with 250–350 Newtons for its cushioning ability⁸. On the other hand, could exposure of 494 Newtons be regarded as risky to the spine? Until now the modeling of the spinal response to whole body vibration and repeated shock has not been reported⁹.

By ISO 2631-1, the crest factor (=peak value/rms value) would rise to more than 9 during the earth unloading period (Fig. 3), which is dangerous and far greater than most vibration exposure. Such events may present as occasional shocks as in this study, and additional methods, such as maximum transient vibration value (MTVV) and vibration dose value (VDV), are suggested as a replacement for the basic evaluation method of root mean square acceleration. However, in a recent U.S Army study adopting ISO 2631-5 as a new

Table 1. Peak shock measured during truck dumping process

Body Part	Vertical	Acceleration (G)		Overall
		Lateral	Longitudinal	
Head	6.51	1.82	6.69	9.51
Neck/Shoulder	5.95	3.65	6.39	9.46

$$\text{overall} = \sqrt{\text{Vertical}^2 + \text{Lateral}^2 + \text{Longitudinal}^2}$$

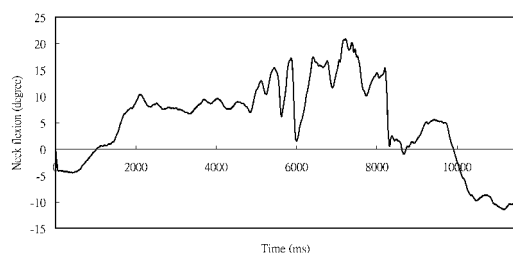


Fig. 2. Flexion degree of neck of the truck driver measured with goniometer during the unloading process.

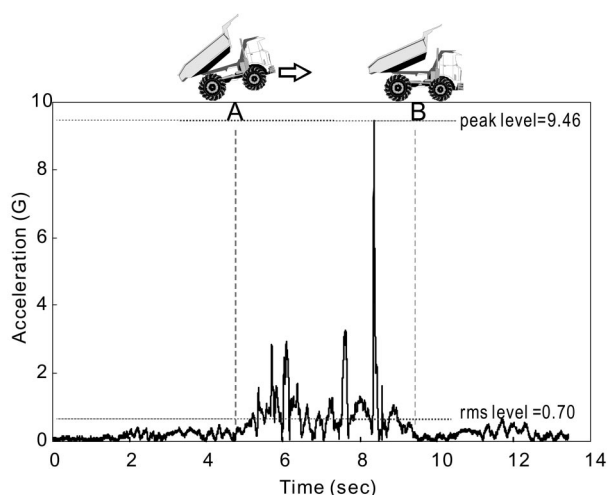


Fig. 3. Overall acceleration at the head during the measurement period (A: truck starts to move; B: truck stops bumping) (unit G: gravitational acceleration = 9.8m/s²),
 $overall = \sqrt{Vertical^2 + Lateral^2 + Longitudinal^2}$

tool and applied to ground vehicles to perform the assessment of repeated shocks, the research results suggest a possible need for a substantial reduction of the MTVV and VDV caution zone as recommended in the ISO 2631-1 standard, and it was even suggested that VDV should serve as a marker for trigger threshold¹⁰. Thus, it might be better to await a ISO-2631-5 consensus, rather than to do further calculation of these traditional vibration values.

In addition to the shock, the muscle co-contractions may exert impacts on the neck¹¹. In this study obvious neck flexion was also recorded, and hyper-flexion may cause compression in the anterior column and distraction in the posterior column. Moreover, increased motions in the sagittal plane accompanied with shear force might induce additional change, which would make the cervical spine susceptible to injury¹².

In summary, although we are not sure that our cases' occupational exposure was a health hazard, we are sure

that truck drivers in unusual dumping operations, because of repetitive shock, neck flexion plus long term vertical whole body vibration, may experience a more than usual vibration hazard and may have an increased risk of prolapsed vertebral disc, including the cervical spine, and probably with early onset. Further epidemiological and ergonomic studies are warranted to explore the causation and mechanism. However, truck weight limits, safe dumping procedures and supervisory actions should be implemented at once.

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