Ministry of Defence

Synopsis of Causation

Whiplash

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Disclaimer

This synopsis has been completed by medical practitioners. It is based on a literature search at the standard of a textbook of medicine and generalist review articles. It is not intended to be a meta-analysis of the literature on the condition specified.

Every effort has been taken to ensure that the information contained in the synopsis is accurate and consistent with current knowledge and practice and to do this the synopsis has been subject to an external validation process by consultants in a relevant specialty nominated by the Royal Society of Medicine.

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1. Definition

1.1. Early medical reports refer to whiplash as 'railway spine'. This term was used in the 19th century to describe the persistent pain and other 'subjective symptoms' that railway passengers and personnel reported following minor railway crashes.

1.2. The modern term of whiplash was first used by Crowe in 1928[1] and is used to describe both the mechanism of injury and the symptom constellation caused.

1.3. Whiplash has been defined by the Quebec Task Force as, "An acceleration-deceleration mechanism of energy transfer to the neck. It may result from rear-end or side-impact motor-vehicle collisions, but can also occur during diving or other mishaps. The impact may result in bony or soft tissue injuries (whiplash injury), which in turn may lead to a variety of clinical manifestations (whiplash associated disorders)."[2]

1.4. Despite an abundance of literature on the subject, the opening line of a Current Concepts Review of whiplash includes the phrase, "for a condition that affects so many people the knowledge base is incomplete."[3]

2. Aetiology

2.1 Whiplash injury is typically the result of an acceleration-deceleration injury. The head is effectively thrown backwards and then forwards in relation to the shoulders. Most often this is the consequence of rear-end or side-impact motor vehicle collisions, but the injury can happen during diving accidents and other mishaps.[2]

2.2 The exact epidemiology of whiplash is essentially unknown.

2.2.1 The Road Accident Statistics Department of the UK Department for Transport, which holds records on vehicle accidents, does not have a classification category specifically for whiplash and therefore could not provide exact figures for its incidence.[4]

2.2.2 The use of the term in the National Health Service is variable for reasons including litigation association and sensitivity. Therefore no information could be provided from hospital figures.

2.2.3 Incident figures from the insurance industry suggest that, for the UK, in excess of 250,000 claims are made each year relating to whiplash, with an estimated annual cost to the economy of at least £1 billion.[5] This figure does not take into account the unknown number of sufferers who do not claim.

2.3 Whiplash injuries are likely to be complex and progressive with firstly muscles, then ligaments, the fact joints and, finally, the brain being injured in sequence with increasing magnitude of impact.

2.4 The spatial position and active motion of the head is mostly under the control of the cervical muscles. Muscles maintain posture and, when subjected to mechanical loads, they respond to counteract the loads and to restore posture. The larger the load, the greater the muscle response, manifested as a greater tensile load in the tissue.[6]

2.4.1 The osteoligamentous region of the neck is capable of supporting only a quarter to one-fifth of the weight of the head, thus illustrating the role of muscle control.[7] Without muscle control, the osteoligamentous structures are unable to hold the head in position, and certainly cannot resist the forced motion that is created in rear-end impacts. Electromyographic studies measure the activity of muscle and have shown that the cervical muscles appear to be the first in the line of defence during a whiplash mechanism and are therefore likely to be injured first.

2.4.2 During a whiplash event the motion of the torso precedes that of the neck and a bullwhip effect is generated in order for the head to remain attached to the torso (Figure 1).

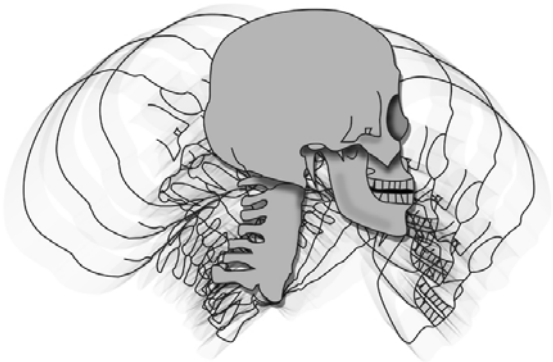

Figure 1. The whiplash mechanism

2.4.3 Shear force is generated at each cervical level and is transmitted up the cervical spine until it reaches the occipital condyles. Here the force can act on the head to cause it to move forward. This shearing action results in relative motion between adjacent vertebrae and is most pronounced at the lower cervical levels where the facet angle is less steep and where most pain is felt.

2.5 There is no consensus as to how the motion of the head and neck causes whiplash-associated disorders but a number of hypotheses have been put forward.

2.5.1 **Hyperextension injury mechanism**.[8] Hyperextension of the neck, even at low velocity rear-end collisions, can produce forces that result in musculo-ligamentous tears, haemorrhage, disc fibre damage and vertebral body fracture.[9]

2.5.2 **Facet joint involvement**. Entrapment of a portion of the facet capsule between facet joint surfaces has been suggested as a cause of the pain.[10,11] Kaneoka *et al* suggest that facet joint pain due to the facets compressing into one another was a cause of pathology,[12] while another study suggests that the facet capsule could be stretched during whiplash.[13,14]

2.5.3 Another hypothesis of an injury mechanism for whiplash is that pressure increases in the spinal canal during whiplash, which applies pressure on the nerve roots and dorsal root ganglion which causes pain signals to be sent to the brain.[15,16]

2.5.4 **Muscular damage**. Investigations of forces produced in muscle during a rear-end crash have found that the sternocleidomastoid muscle is activated before the paraspinal muscles,[6,17] and that the sternocleidomastoid responds with greater relative contraction than either the trapezius or splenius capitis muscles.[6] Another study noted that the greatest deformation occurred in the longus colli muscle followed by the scalenus anterior then the longus capitis, sternocleidomastoid, and scalene posterior muscles.[18] When impact was offset 45° (posterolateral impact), the effect was to shift the burden of the impact over more muscle groups.[19]

2.6 A large amount of work regarding the biomechanical effects of different magnitudes and directions of impact has been performed. If the person anticipates the impending collision (e.g. as a result of awareness of the sound of braking) and thus establishes muscular tone, it is felt that predominantly

bony damage occurs. In contrast, with a lack of pre-impact muscular tone, the anterior cervical muscular structures will be affected first (in the hyperextension phase) and the posterior structures subsequently (with hyperflexion). The majority of research has shown that the structures that are damaged do not fall into either distinct group but are a mixture of both, as the impact is partially anticipated.[20]

3. Clinical Features and Diagnosis

3.1 **Symptoms.** Seventy percent of patients report immediate occurrence of symptoms, although Deans *et al* noted that 22% of patients had not developed symptoms until at least 12 hours after the accident.[21] The whiplash injury often manifests as discomfort in the neck of varying degree, and results in a variety of signs and symptoms referred to as whiplash-associated disorders.[2]

3.1.1 The following table enumerates the incidence of symptoms reported by patients with an acute whiplash injury, as derived from a study of 100 patients:[22]

Symptoms	**%age of patients affected**
Pain and stiffness in the neck and interscapular region	99%
Headache (general)	96%
Headache in the occipital region	78%
Limitation in rotation	49%
Limitation in flexion and/or extension	42%
Loss of concentration	34%
Paraesthesia in the arms or hands	24%
Vertigo and dizziness	24%
General tiredness	19%
Short-term memory disturbances	6%
Personality changes	6%
Disturbances with word finding	5%
Neurological deficit	0%
Radicular symptoms	0%

3.1.2 Recovery typically occurs after 6 weeks. However, in some cases, long-lasting symptoms arise, notably neck pain, neck stiffness and headache.

3.2 Neck injuries are the primary complaint arising from car accidents,[23-25] with 65% of crash victims reporting neck injuries.[24] Neck pain develops in 56% of patients involved in a front or side-impact accident.[26]

3.3 Women are more at risk of whiplash injury than men[2,27] and this is possibly due to the fact that women's necks tend to have less muscle development and are long and slender. The typical patient with a neck injury is a middle-aged woman who has worn a seat belt when involved in a low speed crash.[28]

3.4 The clinical assessment of whiplash requires information to be collected, including the patient history and the nature of the accident to determine the mechanism of injury. This is followed by a physical examination where the patient's general well-being, perceived pain, mobility and neurology are assessed. Functionally the cervical spine should be assessed in the usual 3 planes (flexion/extension, rotation, and lateral flexion) but also for rotation out of both flexion and extension to assess the upper and lower cervical spine.

3.4.1 The patient may have existing limitations that are innate, or due to age or previous injury. It is important to record such findings as they may be

unconsciously suppressed in the light of subsequent symptoms and they are important predictors for an unfavourable outcome.[29]

3.4.2 Other predictors of poor outcome include paraesthesia, muscle weakness of the upper extremities, and radicular deficiency.

3.5 Imaging modalities are utilised depending on clinical signs and symptoms, with plain radiography being undertaken to rule out severe damage such as fracture. Soft tissue injuries are not usually demonstrable by using standard radiography but pre-existing degenerative damage will be shown.[30]

3.5.1 Magnetic resonance imaging (MRI) or computed tomography (CT) is used if there is suspected vertebral, disc, or nerve damage. If damage is not identified, the patient is then discharged from acute care.

3.5.2 Generally with a whiplash injury, these imaging techniques reveal negative results and the physician must make the diagnosis based on the nature and mechanism of the injury and primarily on its indirect effects including pain, disability, palpable oedema, and sleep loss etc.[31]

3.5.3 In terms of diagnosis, fractures of the vertebrae are rare but may be imaged easily using such modalities as plain radiography, MRI and CT scans. However, the majority of injuries are more likely to be soft tissue trauma, which is not always identifiable and, as patients rarely undergo surgery, these injuries often remain undetected.[32]

3.5.4 **Plain radiography** utilises x-rays to image bony structures. Plain radiography is the imaging modality of choice for patients with whiplash injury to identify fracture, dislocation, retropharyngeal oedema, tracheal displacement and instability.[33] Whilst plain radiography allows good visualisation of the topographical arrangement of bony components of the cervical spine, soft tissue changes are generally not well delineated. It has also been demonstrated that a high incidence of cervical pathology may be present despite normal radiographs.[33] Dynamic imaging using plain radiography has shown functional disturbances in patients suffering whiplash injuries.[34]

3.5.5 **CT** allows good visualisation of the topographical arrangement of bony components of the cervical spine and has a higher sensitivity in detecting fractures than plain radiography. Soft tissues are visualised but without structural detail. Cervical discography combined with subsequent CT may be more sensitive than CT alone for determining whether it is a cervical disc lesion that is responsible for a patient's pain and to assess anatomical disc changes such as annular tears.[35]

3.5.6 **MRI** images bone and provides good soft tissue differentiation. In the clinical setting, MRI is reserved for serious cases. Therefore most whiplash patients would not undergo this technique until their problem was long-term. However, by this point it would be unlikely for any oedema or bleeding to be evident. Studies that have used MRI on whiplash patients have demonstrated the presence of anterior longitudinal ligament injury, vertebral end plate fracture, disc injury, disc herniation, and interspinous ligament injury.[36] However, these changes have been observed as normal variants or present in asymptomatic individuals.[37] Other MRI studies have not revealed any specific feature

after whiplash, with the authors of these studies stating that MRI has no role in evaluating whiplash injury.[22,38,39] Soft tissue changes indicating bleeding or oedema were not seen in the cervical images of patients scanned within 2 days of injury[38] which suggests soft tissue damage did not occur in this case. Dynamic imaging using MRI has shown functional disturbances in patients suffering from whiplash injuries.[40] MRI may not always provide the necessary information required to evaluate pathologies such as incomplete ligamentous disruption and paraspinal soft tissue pain.[41] This is largely due to a limitation of spatial resolution and contrast within muscles and ligaments.

3.5.7 **Ultrasound.** The ability to use ultrasound to diagnose whiplash is controversial, and there is little documented evidence available that whiplash related signs can be seen. Ultrasound of whiplash patients has revealed evidence of hypoechoic signals and loss of tissue architectural definition that are consistent with soft tissue injuries such as muscle tears, haematoma, swelling and muscle atrophy.[41-43] The characteristic ultrasound appearance of these pathologies correlates well with documented musculoskeletal injuries. Claims have been made for the use of ultrasound in detecting further pathologies including disc bulges and herniations, as well as abnormalities of the facet joints and paraspinal muscles.[44] The findings of this study must be viewed with caution (it is only published as an abstract on the internet and thus may not have been peer reviewed). However, these results are not implausible, as the use of ultrasound to identify pathology of the structures mentioned has been achieved in other studies.[45-47]

3.5.8 An inherent risk of imaging is that without knowing the pre- and post-injury state of the cervical region, it is impossible to know what changes have taken place as a result of injury. Those features identified as injury-related may have been present before the accident, may represent normal variants, or just be natural degenerative changes due to ageing. To verify changes, the ideal situation would be to have “before” and “after” images to make a valid assessment of those changes taking place. As this is not feasible in the clinical setting, imaging findings must be matched to symptoms, compared to a contralateral image (assuming this is free from pathology) and compared to asymptomatic individuals.

4. Prognosis

4.1 It is impossible to generalise regarding the prognosis of whiplash.

4.2 The difficulties in evaluating damage to anatomic structures imply an inability to predict prognosis accurately.

4.3 In normal practice, MRI is not used immediately after the accident in the absence of neurological deficit. Post-mortem examinations have shown severe cervical pathology in some cases and so two main categories of patient have been suggested: those in whom there is a cervical 'sprain' and those with much more severe structural damage. Whilst the former generally heal rapidly, the latter may progress to secondary biomechanical or degenerative abnormalities.[3]

4.4 One of the problems alluded to in most research is the presence of pre-morbid spinal pathology. In asymptomatic subjects, abnormal MRI scans of the cervical spine have been seen in 28% of individuals over 40 years old.

4.5 Schrader *et al* found that in patients between 1 to 3 years post-accident, there was no significant difference in chronic symptoms between controls and accident victims.[48] These results confirm the findings of Bovim *et al* and Makela *et al* that neck pain is a common finding in the general population.[49,50]

4.6 Spitzer *et al* found that 22% of people with compensated claims for whiplash injuries did not appear injured at the accident site.[2]

4.7 The biopsychosocial aspects of whiplash are at best theoretical and thus provide a potential area for compensation claims. From a clinical point of view, whiplash is a large subject with a huge spectrum of pathology. Most of the patients seen with recalcitrant problems would be referred to specialist pain management clinics. These are multidisciplinary clinics run by consultant anaesthetists with a special interest in this area. The clinics often involve psychiatrists and specialist nurses. The anaesthetists are experts in analgesia and the aim is to tailor an analgesic regime to the patient's specific requirements. The multifactorial nature of the whiplash injury problem requires a coordinated treatment plan involving all the other specialties depending on the requirements of the patient.

5. Summary

5.1 Whiplash injury was first recognised in the early 1920s. Since this first report the number of road users has increased, leading to an increase in the incidence of this injury. Typically, 250,000 insurance claims are made annually in the UK alone with a cost to the economy of at least £1 billion.

5.2 Whiplash is an injury of high socioeconomic importance, and the ability to understand and assess this injury would benefit from a diagnostic technique with high specificity and sensitivity.

5.3 Whiplash injury is the result of a sudden movement of the head typically occurring as a result of a rear-end vehicle collision. Victims typically report varying levels of pain emanating from the neck region, although the exact cause of pain is yet to be established. This unknown patho-anatomy is a possible reason as to why suitable diagnostic procedure and treatment strategies have not been established. Recovery typically occurs after 6 weeks, but long-term sufferers do occur.

6. Related Synopses

Neck Pain

7. Glossary

anterior longitudinal ligament	A very strong ligament running down the front of the spinal vertebrae.
atrophy	Wasting away or diminution.
cervical discography	Investigation looking at the discs as opposed to the bony elements in the neck region.
dislocation	Total loss of congruity between two articulating surfaces.
dorsal root ganglion	The fusion of nerve fibres (junction box) which forms a lump (nodule) to allow the transference of information.
electromyographic	Investigation that measures the response of muscles to nerve stimulation.
epidemiology	The study of the distribution, determinants, and control of diseases in populations.
facet angle	The angle of the articulation between two adjacent vertebrae.
facet capsule	The sac around a facet joint. It is lined with a membrane that secretes a lubricating fluid, which allows movement to take place.
facet joint	The articulation between two adjacent vertebrae.
haematoma	Bruise.
hypoechoic	A region in an ultrasound image where the echoes are weaker than in surrounding areas.
interspinous	Between the spinous processes. A spinous process protrudes from the back of each vertebra.
longus capitis	Muscle that runs between the neck and the occipital bone of the skull. Its action is to twist and flex the neck anteriorly.
longus colli	Muscle of the neck that twists and flexes the neck anteriorly.
occiptial condyles	Bones involved in the joint between the head and the spine.
osteoligamentous	Relating both to the bones and ligaments.

paraesthesia	Abnormal sensation.
paraspinal	Adjacent to the spinal column.
posterolateral	Behind and to the outer side.
retropharyngeal oedema	Swelling at the back of the mouth.
scalenus (scalene)	A group of muscles of the neck.
shear force	The tearing of two surfaces away from each other.
splenius capitis	Muscle in the neck that rotates the head and extends the neck.
sternocleidomastoid	Muscle located on the front of the neck that turns the head from side to side.
tensile	Relating to forces applied to a body that tend to stretch, or elongate, the body.
tracheal displacement	Displacement of the windpipe.
trapezius	Muscle at the back of the neck.

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