Predicting prognosis in whiplash

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In the last decade there has been considerable progress in the field of whiplash injury with respect to recovery and outcome. The aim of this review is to present the evidence base with respect to the assessment of whiplash injury. The emphasis will be placed upon identifying those at risk of poor recovery by reviewing the subjective assessment of whiplash injury (crash related factors, pain, disability, dizziness and psychological disturbance) and those "objective" tests (probably more accurately described as "psychophysical" tests) that can be performed easily in the clinical setting.

LEARNING OUTCOMES
TO SUPPORT PHYSIO FIRST QAP

1 Increase understanding of pathology associated with whiplash injury.
2 Increase knowledge of risk factors associated with poor outcome in whiplash injury.
3 Increase knowledge of clinical approaches to identifying individuals at risk of poor recovery following whiplash.
4 Increase knowledge of clinical approaches to managing individuals at risk of poor recovery following whiplash.

Whiplash prognosis: what is the role of pathology?

There are scores of animal and human cadaver and computer simulation studies that have identified the cervical spine facet joints (Dong *et al* 2008; Quinn *et al* 2010), intervertebral discs and ligaments (Krakenes *et al* 2002, 2003; Vetti *et al* 2009), muscles (Brault *et al* 2000; McCully & Faulkner 1985; Scott & Sanderson 2002), dorsal root ganglia (Svensson *et al* 1998; Eichberger *et al* 2000), and vertebral artery (Carlson *et al* 2007; Ivancic *et al* 2006) as being susceptible to injury during the whiplash mechanism. The majority of the experimental evidence implicates the facet joint, and most probably the facet joint capsule, as a primary cause of symptoms following whiplash injury. Clinical studies demonstrating significant pain relief in chronic neck pain cohorts following nerve blocks, or radiofrequency neurotomy lend support to this view (Bogduk & McGuirk 2006). The *experimental* evidence for facet joint injury following whiplash is compelling.

In-vivo studies of pathology following whiplash injury are historically poorly represented in the literature (Kaale *et al* 2005) and they have not been without their critics (Ferrari *et al* 2010). Freeman and colleagues (2010), in a high-quality study, demonstrated substantial neuroradiographic differences in the frequency of cerebellar tonsillar ectopia (CTE or Chiari malformation) between 1,195 subjects with neck pain with and without a recent history of motor vehicle related crash trauma. Indeed, the authors concluded by criticising previous research on psychosocial causes of chronic pain following whiplash for failing to account for a possible neuropathologic basis for the symptoms.

A recent investigation, taken within 48 hours of the injury and using a turbo STIR sequence on a sample of subjects, a proportion of which demonstrated no objective signs, i.e. Quebec Grade I, documented occult fractures and bone contusions of vertebral bodies, and strains, tears, haematomas and perimuscular fluid in muscle (Anderson *et al* 2012).

Muscle damage has also been demonstrated (figure 1) in the acute stage of injury using diagnostic ultrasound scanning (Roshier 2005) and there has been anecdotal surgical evidence of muscle rupture, facet joint capsule rupture and ligament sprain (Gunzberg & Szpalski 1997).

In the absence of Chiari-type symptoms, i.e. a history of whiplash injury and persisting suboccipital headache, in combination with headache worsened by cough, or bilateral sensory, or motor deficits in the upper extremities (Freeman *et al* 2010), many people with high levels of pain and disability will have no precise, identifiable injury that can be linked to their symptoms using currently available technology. Indeed, the majority of the injuries found in cadaver and animal models cannot be identified by clinically available diagnostic modalities. The prospect of imaging devices with higher resolution may provide a link between tissue injury and outcomes in the future, but for the present we must rely on the clinical history and examination to provide a window upon prognosis.

> "MANY PEOPLE WITH HIGH LEVELS OF PAIN AND DISABILITY WILL HAVE NO PRECISE, IDENTIFIABLE INJURY THAT CAN BE LINKED TO THEIR SYMPTOMS, USING CURRENTLY AVAILABLE TECHNOLOGY"

Prognosis: history and clinical examination

PRE-INJURY STATUS

The prognostic role of pre-injury neck pain remains unclear (Carroll *et al* 2008), and those reviews that have identified an effect for the presence of pre-injury neck pain have described it as "small but significant" (Walton *et al* 2013). The effect size for history of headache suggests no significant risk of persistent problems (Walton *et al* 2013) and Carroll *et al* (2008) found "no scientifically admissible" studies which addressed the impact of disc degeneration on recovery from whiplash injury, while a more recent one-year prospective study demonstrated that pre-existing degeneration on magnetic resonance imaging (MRI) was not associated with prognosis (Kongsted *et al* 2008a).

DEMOGRAPHIC VARIABLES

The evidence varies and is subject to the role of age and gender as prognostic factors for recovery following whiplash injury. However, in those reviews that have identified older age and female gender as a prognostic for poor recovery, the effects are negligible to modest (Carroll *et al* 2008; Walton *et al* 2013), with the prognosis for females being slightly worse; female OR = 1.64 (Walton *et al* 2013). Having less than post-secondary education has also been associated with poor prognosis (Walton *et al* 2013).

CRASH RELATED FACTORS

Crash related factors include collision direction, use and type of head restraints, speed of impact, awareness of collision, position in seat and whether the person's head was turned at the time of the accident. While experimental data has suggested that having a rotated neck position at the time of impact doubles the strain through the facet capsule (Siegmund *et al* 2008; Winkelstein *et al* 2000), clinically orientated systematic reviews have identified few crash related factors that have predictive utility. Carroll *et al* (2008) concluded there was no association between crash related factors and outcome, except for a modest effect for those injured while driving a vehicle fitted with a tow bar having a poorer prognosis. Not wearing a seat belt at the time of the collision appears to lead to a two-fold increase in the risk of developing whiplash related pain and disability at 12-month follow-up (Walton *et al* 2009). Sterling makes the interesting point that the factor of the individual not wearing their seat belt is likely to be under-reported in jurisdictions where use of the seat belt is compulsory by law, so the incidents associated with this factor may be even higher than identified (Sterling & Kenardy 2011). More recently Walton *et al* (2013), using rigorous inclusion criteria in a systematic review and meta-analysis, concluded that parameters of the collision show no predictive ability in identifying risk of poor outcome. Variables with strong evidence of no effect include, "unprepared for collision," no head restraint in use and that the vehicle was stationary when hit (Walton *et al* 2009).

To try to explain the lack of evidence, some authors have noted that crash related factors rely heavily upon the self-report of the claimant, making them highly susceptible to both recall and desirability bias; the secondary motive influencing reports (Walton *et al* 2013).

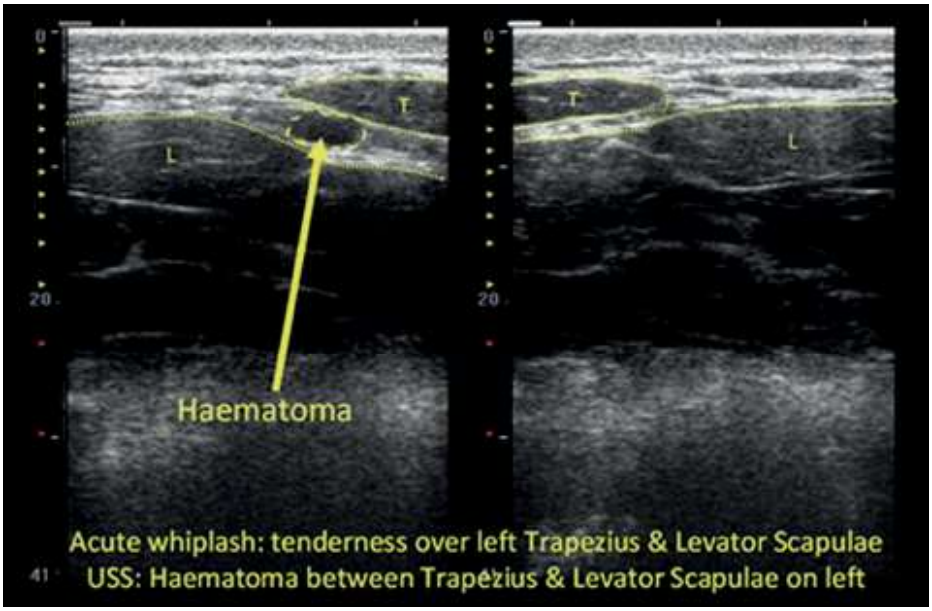

FIGURE 1: Cervical spine ultrasound image courtesy of Dr Donal McNally / Dr Mandy Roshier / University of Nottingham

Presenting signs and symptoms

HISTORY

Initial post-injury pain intensity, number and severity of injury related symptoms, and the presence of radicular signs or symptoms appear to be substantial predictors of recovery (Carroll *et al* 2008; Walton *et al* 2009; 2013). Walton *et al* (2013) also recently found a six-fold increase in risk of persistent pain or disability at follow-up in those complaining of high neck pain intensity defined as a score of 5.5/10 on a Visual Analogue Scale (VAS). Self-reported headache at inception is associated with a significant increase in the risk

> "REPORTS OF LOW BACK PAIN POST-INJURY DEMONSTRATE A SMALL, BUT SIGNIFICANT RISK FOR PERSISTENT PROBLEMS"

of persistent problems being reported at follow-up, and reports of low back pain also demonstrate a small, but significant risk for persistent problems (Walton *et al* 2013). In one cohort, 30% of acute whiplash patients presented with a neuropathic pain component, as measured by the Leeds Assessment of Neuropathic Symptoms and Signs pain scale (S-LANSS), a score of >12 on this scale predicted poor recovery (Sterling & Pedlar 2009).

The most commonly used measure of disability in whiplash is the neck disability index (NDI), a 10-item questionnaire that scores, from 0-5, the activities of daily living pertaining to the neck region (Vernon & Mior 1991). The scores are summed to give a total of 50 or, multiplied by two, to give a percentage score. A score of 30% or higher in one meta-analysis is predictive of poor recovery (Walton *et al* 2013). In a more recent study designed to establish a clinical prediction rule for use following whiplash injury, a score of >40% predicted chronic moderate / severe disability, with a score of 32% predicting recovery (Ritchie *et al* 2013). This latter study also included age and a measure of post-traumatic stress response in the clinical prediction rule.

Dizziness appears to be a common, yet overlooked symptom following whiplash injury. In one cohort, as many as 75% of subjects complained of dizziness (Treleaven *et al* 2003). The unsteadiness that can occur following whiplash is hypothesised to arise from injury and disruption to the deep muscle spindles of the cervical spine, and the mechanoreceptors of the facet joint capsule. One theory suggests that distortion of the afferent signals from the muscle spindles leads to a conflict of information in the dense anatomical reflex connections between the muscle spindles, the eyes or cervico-ocular reflex, and the vestibular system or vestibulo-ocular reflex (Treleaven *et al* 2008). Indeed, there is increasing objective evidence of disturbances to smooth pursuit eye movement control, proprioception of the head and neck and postural instability following whiplash injury (Treleaven *et al* 2005, 2006; Field *et al* 2008); however, these sensorimotor signs and symptoms do not appear to be useful as predictive factors following whiplash injury (Kongsted *et al* 2008b).

PHYSICAL EXAMINATION

Despite its continued use as one of the sole objective prognostic measures in whiplash injury assessment, cervical range of motion has been found to have no significant effect on recovery (Williams *et al* 2007) and a meta-analysis confirms these findings (Walton *et al* 2009).

Widespread sensory change has been identified in a sub-group of 20% of whiplash injured subjects (Sterling *et al* 2006). This manifests as reduced pressure pain thresholds (PPT), i.e. the point at which pressure becomes pain, at areas removed from the site of injury, and has a heightened sensitivity to a cold stimulus, both of which are indicative of an augmented central pain processing that has also been identified in fibromyalgia.

In one systematic review, cold hyperalgesia was found to be associated with a poorer outcome (Williams *et al* 2007) and Walton *et al* (2011a) have demonstrated that PPTs at a site over the tibialis anterior muscle significantly predicted the variance in short-term outcome in individuals with acute whiplash injury. The authors concluded that PPTs represent a "promising addition" to the clinical assessment of traumatic neck pain.

PSYCHOLOGICAL EXAMINATION

Carroll *et al* (2008) found that psychological factors are prognostic of recovery in whiplash injury. Passive coping, helplessness, fear of movement, and anxiety all predict a slower recovery. While catastrophising appears to have a significant effect on recovery, depressive symptoms appear to play no role in outcome (Walton *et al* 2009). Fear of movement appears to contribute to the relationship between pain and disability post whiplash injury (Kamper *et al* 2012), and lower expectations of recovery have been shown to predict poor recovery (Holm *et al* 2008).

In their systematic review of psychological risk factors, Williamson *et al* (2008) concluded that decreased self-efficacy, i.e. the confidence to perform activities despite pain, and a post-traumatic stress reaction are predictive of poor recovery, but were unable to identify any other prognostic psychological factors. Sterling & Kenardy (2008) suggested that a score of >26 on the impact of event scale (IES) questionnaire as a measure of post-traumatic reaction indicates risk of poor recovery. In one study, using a group based trajectory model at three months post whiplash, 22% of participants met the criteria for a probable PTSD diagnosis decreasing to 17% at 12 months (Sterling *et al* 2010). It was further noted by Sterling & Kenardy (2011) that these data are surprisingly similar to that documented for people

> "DIZZINESS FOLLOWING WHIPLASH IS HYPOTHESISED TO ARISE FROM INJURY AND DISRUPTION TO THE DEEP MUSCLE SPINDLES OF THE CERVICAL SPINE"

RISK FACTORS
Less than post-secondary education
Failure to wear a seat belt
Post-injury pain >5.5/10
Number and severity of injury-related symptoms
Presence of radicular signs and symptoms
Post-injury headache
Post-injury low back pain
Neuropathic pain
Neck Disability Index score >40%
Post traumatic stress symptoms
Catastrophising
Reduced pressure pain threshold at shin
Cervical spine cold hyperalgesia

TABLE 1: Risk factors for poor recovery following whiplash injury

with more severe traumatic injury who required hospitalisation or admission to intensive care.

In a prospective cohort followed up for three years, factors such as age, NDI score, cold hyperalgesia and post-traumatic stress symptoms that had been measured at four weeks post injury, showed a classification rate for non-recovered, high pain and disability in 60% of the group at the three-year mark (Sterling *et al* 2006). In a latter study, the at-risk subjects presented with high levels of pain, disability, an unresolved post-traumatic stress response and increased sensitivity to both mechanical pressure (PPT) at areas removed from the site of injury and cold stimuli. This group has been described as having "complex whiplash" (Sterling & Kenardy 2008).

As discussed earlier, a recent study has derived a clinical prediction rule for identifying the factors of recovery and non-recovery that include age, the NDI score and the hyper-arousal subscale of the post-traumatic diagnostic scale (PDS). An individual who meets the following three criteria is likely to develop moderate / severe disability: NDI >40%, age >35 years, and >6 on the hyper-arousal subscale of the PDS (Ritchie *et al* 2013; Foa *et al* 1997). Hyper-arousal symptoms include having trouble falling asleep, feelings of irritability, difficulty concentrating, being overly alert, and being easily startled. Conversely, an individual who meets the criteria of NDI <32% and is under 35 years of age is likely to fully recover.

Screening for risk of poor recovery in the clinic

Factors that appear to be strongly predictive of poor recovery following whiplash injury are shown in table 1.

The subjective self-report aspects, e.g. pain levels, sites of injury, etc. are easily assessed in the clinic. Assessing disability levels and screening for neuropathic pain and a post-traumatic stress reaction, however, requires the use of standardised, validated questionnaires (table 2).

The mnemonic "C-SPINE", as shown in figure 2 (overleaf) can be used to aid recall of the more important factors that appear to be prognostic of poor recovery. In the clinical setting it is useful to informally screen by probing with the items listed under "ASK" and consider the basic management suggestions provided. If the clinician feels that the patient requires more formal testing, the most commonly used screening tools are listed at the foot of each column.

In addition, an interactive site that calculates the total NDI score automatically, and which can be completed relatively quickly by the clinician during examination, is available at **www.chrisworsfold.com/ndi**

For assessing pressure pain thresholds, an algometer – a relatively inexpensive hand-held device that reliably quantifies tenderness by measuring the precise force required to produce the first sensation of pain – can be used (figure 3, overleaf).

Data published in acute and sub-acute neck pain patients show that lower scores, i.e. 0-25 quartile range from <1.5 Kg/f in the upper trapezius and <2.5Kg/f at the Tibialis Anterior site (Walton *et al* 2011b) increase the risk of ongoing disability at one to three months. Mechanical hyperalgesia is a common finding in the majority of neck pain patients, but increased tenderness at a location removed from the area of trauma, such as the shin which, as mentioned previously, is commonly used in the research setting, strongly suggests the presence of widespread mechanical hyperalgesia following whiplash injury.

To examine for signs of cold hyperalgesia, a Thermoroller cooled to 15°C (figure 4 overleaf) can be used. However, recent work suggests carrying out this examination with a simpler method that involves the application of an ice pack to the posterior aspect of the cervical spine for 10 seconds (Maxwell & Sterling 2013). Where the patient rates the resulting sensation as painful and scores > 5/10 on the VAS, the presence of cold hyperalgesia is strongly suggested. A score < 1/10 on the VAS, strongly suggests the absence of cold hyperalgesia.

A logical evidence-based pathway for screening for poor recovery would be NDI >40%, screening for:
1. post traumatic stress response
2. widespread hyperalgesia (PPTs at shin – algometer)
3. cold hyperalgesia at the neck (Thermoroller / ice pack).

Managing the person at risk of poor recovery

Exercise and activity should be used in the treatment of chronic whiplash on condition that the outcome is monitored closely and treatment only continued if there is improvement, as effect sizes for these treatments are small (Sterling 2014) and it is likely that it is only a sub-

QUESTIONNAIRES	DESCRIPTION	COMMENTS
Neck Disability Index (Vernon & Mior 1991)	Disability measure	>40% suggests increased risk of poor recovery
S-LANSS (Bennett *et al* 2005)	Neuropathic pain measure	>12 suggests increased risk of poor recovery
Impact of Event Scale (Horowitz *et al* 1979)	Post-traumatic stress reaction screening	>26 more than six weeks post injury suggests increased risk of poor recovery

TABLE 2: Identifying poor outcome following whiplash injury

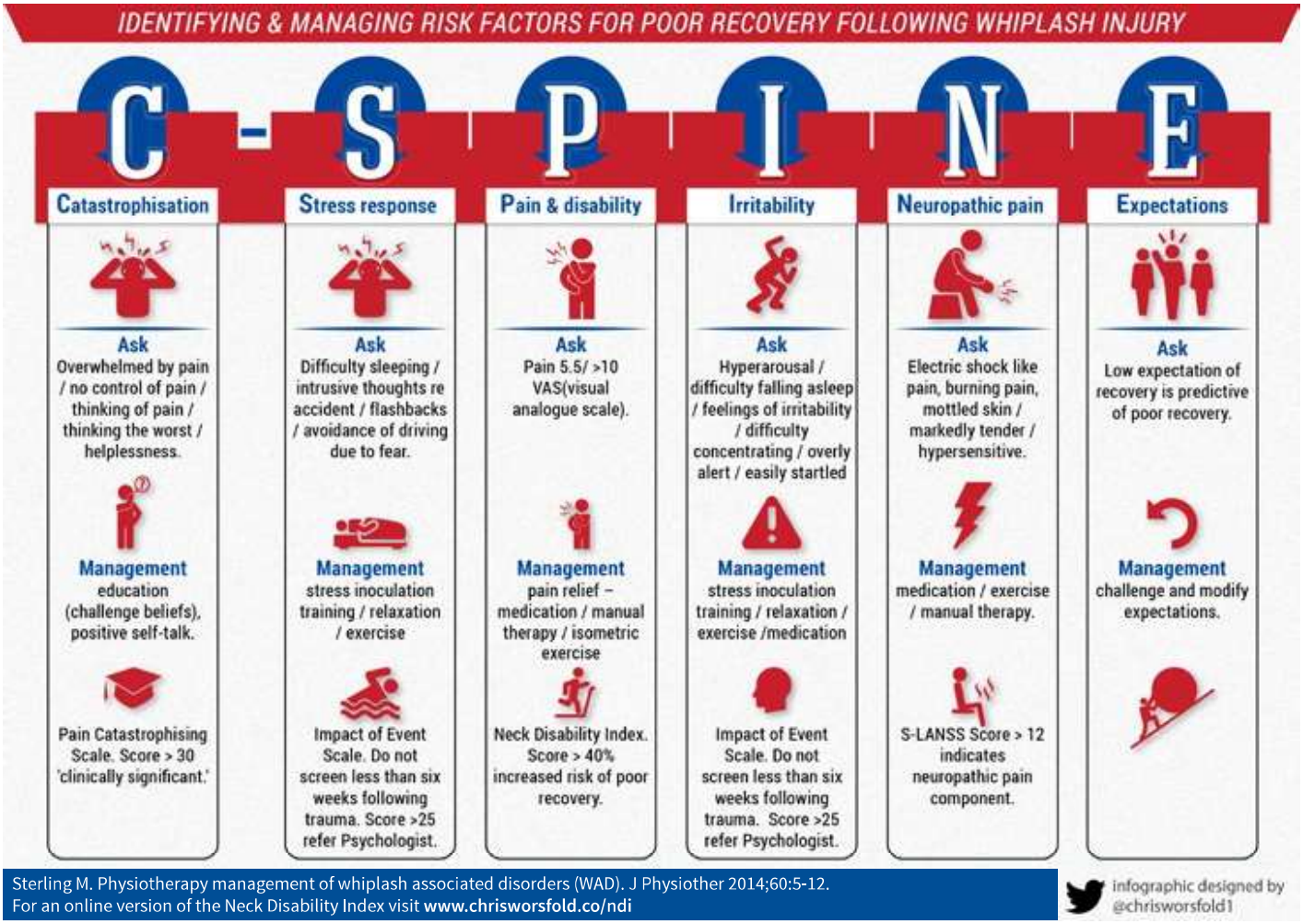

FIGURE 2: Risk factors for poor recovery following whiplash injury. The "C-SPINE" mnemonic

group that responds to this approach. There is no evidence for one specific exercise approach to be favoured over another.

Clinical evidence would suggest that a trial of neuropathic pain medication may be appropriate, although this has not been examined in chronic whiplash injury, and a recent trial in acute whiplash revealed poor tolerance of side effects (Jull *et al* 2013).

FIGURE 3: Algometer

With reference to catastrophisation, low expectation of recovery and post-traumatic stress symptoms, the clinician clearly needs to make a judgement using their confidence and training to deal with these psychological factors. Fruitful avenues to explore in the clinic may include relaxation training to alleviate a stress response and education interventions directed at modifying low expectations of recovery.

It may also be possible to modify catastrophisation through a cognitive behavioural therapy (CBT) approach

FIGURE 4: Thermoroller cooled to 15°C

that involves identifying and modifying negative thoughts related to pain. This may also involve "behavioural experiments". Where fear of re-injury or fear of movement is identified as an obstacle to recovery, recent research has demonstrated good outcomes in the use of movement-based in-vivo exposure interventions to decrease this fear (Robinson *et al* 2013).

So, a psychologically informed physiotherapy for those presenting with lower scores (Sullivan *et al* 2011) on the Pain Catastrophising Scale (PCS) and Impact of Event Scale (IES) may well be appropriate, but higher IES scores >25 (Sterling 2014) will require referral to a clinical psychologist for cognitive behavioural therapy. A recent study of CBT intervention in people with chronic whiplash and symptoms of a post-traumatic stress response led to decreased psychological symptoms and decreased pain-related disability (Dunne *et al* 2012).

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