Dose response and structural injury in the disability of spinal injury

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Abstract

Introduction In traumatic injury there is a clear relationship between the dose of energy involved, structural tissue damage and resultant disability after recovery. This relationship is often absent in cases of non-specific chronic low back pain that is perceived by patients as attributed to a workplace injury. There are many studies assessing risk factors for non-specific low back pain. However, studies addressing causality of back pain are deficient.

Purpose To establish whether there exists a causal relationship between structural injury, low back pain and spinal disability.

Methods Retrospective analysis of prospectively gathered validated spinal outcome measures [Oswestry disability index (ODI), low back outcome score (LBO), modified somatic perception (MSP), modified Zung depression index (MZD)] between patients with healed high energy thoracolumbar spinal fractures and patients with self-perceived work-related low back pain. Causality was established according to two of Bradford Hill's criteria of medical causality, temporal and dose–response relationships.

Results Twenty-three patients with spinal fractures (group 1) of average age 44 years were compared to 19 patients with self-reported back pain in the workplace pursuing claims for compensation (group 2) of average age 48 years. Both groups were comparable in terms of age and

sex. The average ODI in group 1 was 28 % (SD 19) compared to 42 % (SD 19) in group 2 ($P < 0.05$). Similarly, LBOS was 39.7 versus 24.3 ($P < 0.05$), MSP 4.3 versus 9.3 ($P < 0.05$) and MZD 20.2 versus 34.8 ($P < 0.05$) in groups 1 and 2, respectively.

Conclusion Despite high-energy trauma and significant structural damage to the spine, patients with the high energy injuries had better spinal outcome scores in all measures. There is no 'dose–response' relationship between structural injury, low back pain and spinal disability. This is the reverse of what would be anticipated if structural injury was the cause of disability in workplace reported onset of low back pain.

Keywords Non-specific low back pain · Vertebral fractures · Outcomes · Work-related injury · Dose–response relationship

Introduction

The lifetime incidence of back pain in western countries is 70 % [1, 2]. This is often associated with occupational injuries [3] with 52–60 % being reported as work-related [2] and 47–77 % of such patients seeking compensation [4]. Each year in the UK 120 million working days are lost because of back pain [5]. The socio-economic burden of LBP is therefore significant and increasing with the indirect costs of this loss of productivity thus far exceeding the substantial medical costs involved [6].

The majority of cases of non-specific low back pain (NSLBP) are self-limiting. The prognosis for most patients on sick leave to resume work is good [7] with 70 % of patients on sick leave returning to work within 1 week, and 90 % within 2 months [1]. The complexity of the spine

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often renders it difficult to identify the specific causes or trigger points in patients presenting with low back pain. 85 % of patients with back pain have unexplainable symptoms [8]. The aetiology of NSLBP is therefore considered as multifactorial [9], with clear morphological alterations only being found in 10–20 % of cases [8].

The percentages of patients with acute LBP that go on to a chronic state varies between studies from 2 to 34 % [10]. Why some individuals with NSLBP progress to develop disabling chronic pain in the absence of any significant structural injury still remains unknown with psychosocial rather than medical factors being held responsible [11, 12]. Medicalisation [13], sick leave, work absence [14] and a claim for financial compensation [15] have all been shown to be strongly linked with poor prognosis in patients struggling with NSLBP.

Establishing a causal relationship in patients with back pain is therefore challenging. Subgroups of patients with low velocity injury and self-reported LBP in the workplace have poor functional outcomes in long-term studies. The opposite is true in patients with significant high-energy spinal fractures. These groups of patients have been shown to have satisfactory long-term outcomes in terms of both pain and functional improvement with between 60 and 80 % of patients returning to work [16–19].

The majority of existing studies relating to non-specific low back pain identify an association between potential risk factors and outcomes. However, such associations do not infer a causal relationship [20]. Establishing causality is important particularly with regards to work-related injury and disability from low back pain. Patients with work-related injuries are more likely to commence litigation [21]. However, such injuries may not be a causative factor for back pain and related disability, but may be associated with psychosocial factors. Why should industry and economy suffer from non-causal back pain when in fact such perceived injuries may not be responsible for patient disability?

The purpose of this study was to establish whether there exists a relationship between structural injury, low back pain and spinal disability according to Sir Bradford Hill's criteria of medical causality [22].

Methodology

To address this causality, a retrospective analysis of prospectively gathered spinal outcome measures consisting of the Oswestry disability index (ODI), low back outcome score (LBO), modified somatic perception (MSP) and modified Zung depression index (MZD) was compared in two contrasting cohorts of patients at the extremes of an energy spectrum. Contrasting cohorts were selected to

highlight and amplify any definite structural injury effect on disability.

Group 1 consisted of 23 consecutive patients admitted to a university hospital between 1996 and 2009 under the care of the senior author for high energy isolated unstable thoracolumbar and lumbar spinal fractures which were treated with surgical stabilisation. They were then followed-up until satisfactory clinical and radiographic fusion and completed standard spinal assessment questionnaires relating to spinal disability at final review. This was taken as the time of removal of metalwork as was standard practice at that time. Polytrauma and conservatively managed patients as well as those who failed to return for follow-up were all excluded.

Group 2 consisted of 19 consecutive patients under the care of the senior author who were recruited from a medico-legal clinic. All of these patients were presenting for medico-legal compensation claims relating to self-reported low back pain perceived to be due to a workplace injury over the same time frame. Patients with neck pain, workplace accident, road traffic accidents or other physical injuries were excluded. The energy involved in such cases was negligible or difficult to quantify. A thorough history and examination was performed along with patient completion of validated standard spinal assessment questionnaires.

Statistical analysis was performed using the Mann–Whitney *U* test using SPSS version 16. Causality was assessed using Sir Bradford Hill's criteria for medical causality [22]. He proposed a minimal set of nine conditions required to establish a causal relationship. For the purpose of this study two of these criteria were used. A temporal relationship, that is, did the cause of back pain precede the effect of back pain and spinal disability; secondly as the dose of energy involved in the traumatic event increased, did the resulting disability also increase, that is a dose–response relationship.

Results

Patient demographics are presented in Table 1.

Patients in group 1 were assessed following satisfactory clinical and radiographic union of isolated surgically stabilised thoracolumbar spinal fractures. The average time from surgical stabilisation and removal of metalwork was 41 months. The majority of fractures were at the level of the first lumbar vertebrae (Fig. 1).

All 19 patients in group 2 related their symptoms to be work-induced injuries as a result of manual handling whilst performing their regular duties. All of these patients had manual handling training and all complained of predominant low back pain. 47 % of patients within this group had

Table 1 Patient demographics [mean/SD (range)]

Groups	No. of patients	Age	Sex	Final follow-up (months) ^a
Thoracolumbar spinal fractures	23	44 (26–66)	8F; 15M	41 (14–89)
Workplace injury	19	48 (30–64)	4F; 15M	38 (18–53)

^a Average time between onset of symptoms and review in clinic (workplace injury); fracture fixation and removal of metalwork (thoracolumbar fractures)

Fig. 1 Frequencies and levels of thoracolumbar spinal fractures

back pain prior to the alleged incident. All but one patient within this group were not undertaking any form of physical exercise and all remained on a cocktail of analgesia.

47 % of patients within this group remained in some form of employment with the remainder being unemployed as a result of their symptoms. All patients within this group had obstacles to recovery or yellow flags in addition to that of their compensation status and all had completely normal neurological examinations. On national guidelines, none of these patients warranted any form of specialised imaging but only 3 (16 %) patients were not investigated with specialised imaging techniques. The remainder had either X-rays of their lumbar spine $\pm$ MR ($n = 16$) imaging. All of these had been organised by physicians prior to review. The majority of these showed normal age related changes and all failed to identify focal pathology that may have correlated with patient symptoms.

The average ODI for patients in group 1 was 28 % (SD 18.5), (moderate disability) compared to 42 % (SD 18.6) in group 2, (severe disability) ($P = 0.031$). The average LBO was 39.7 (SD 16.1) in patients in group 1 representing fair back function versus 24.3 (SD 9.9) in patients in group 2, indicating poor function, ($P = 0.008$). The modified somatic perception (MSP) was 4.3 (SD 4.3) versus 9.3 (SD 6.3), ($P = 0.027$); and MZD was 20.2 (10.9) versus 34.8 (8.4) ($P = 0.001$) in groups 1 and 2, respectively. Patients with self-reported back pain secondary to a self-perceived injury in the workplace were significantly more disabled;

had poor levels of back function; were more somatized and had higher levels of depression when compared to those with thoracolumbar spinal fractures. The average visual analogue score for leg and back pain in group 2 was 3.7 and 5.7, respectively, ($P = 0.016$) indicating that this group of patients were back pain dominant. Visual analogue scores for the spine fracture cohort were not recorded and therefore no comparisons could be made relating to these (Table 2; Fig. 2).

A subgroup analysis was performed comparing the outcomes between patients with and without previous back pain within group 2. Patients with previous back pain had lower levels of back function and greater scores on the MZD index (Table 3). Any further constructive analysis of this was not plausible due to very small numbers. Statistical analysis was therefore not performed.

Discussion

Disability associated with work-related LBP is an increasingly serious societal problem. Although most injured workers return quickly to work, a substantial number do not [23]. Significant proportions of such claimants do not have any verifiable evidence of significant injury and are therefore self-reported episodes of back pain occurring in the workplace.

Identifying the cause of low back pain secondary to workplace accidents is important and often overlooked in the literature. Structural causes which can be identified make up to only 20 % of back pain cases in total. In the remainder no cause is often found. Many publications assess risk factors for chronicity and continuing work absence. These are primarily psychosocial. Although these are important in enabling and directing intervention thereby preventing or reducing the chronicity of patient symptoms and ultimately societal costs, they fail to address the issue of causality. Is non-specific work-related injury responsible for chronic low back pain?

The answer to this question is important and one which many medical and legal experts try to address on a regular basis within our compensation and litigation-orientated culture. If back pain is caused by such work-related injury then a claim for compensation may be valid and institutions should be made to address such causative factors. However, if not, then awareness of this needs to be raised to prevent opportunistic claims.

Sir Bradford Hill, a medical statistician, proposed a minimal set of nine conditions which are required to establish a causal relationship. The purpose of this study was to assess one of these criteria, the dose–response relationship. As the dose increases in magnitude the cause or effect should also increase in similar magnitude. The

Table 2 Summary of spinal outcome measures

	ODI (mean/SD)	LBOS (mean/SD)	MSP (mean/SD)	MZD (mean/SD)
Group 1 (Fracture)	28.3/18.5	39.7/16.1	4.3/4.3	20.2/10.9
Group 2 (NSLBP)	42/18.6	24.3/9.9	9.3/6.3	34.8/8.4
<i>P</i> value	0.031	0.008	0.027	0.001

Fig. 2 Mean outcome values with 95 % CI between the two groups

presence of this relationship is strong evidence for a causal relationship. This is often of a threshold relationship manifesting itself as a sigmoid-shaped curve (Fig. 3). Patients in this study with the high energy spinal fractures had less disability and better back function when compared to the patients with work-related injuries. There is therefore no dose–response relationship. The findings of this study also correlate with that by Giannoudis et al. [24] in which they conclude the absence of a dose–response relationship between the magnitude of trauma severity and the incidence of whiplash injury.

47 % of patients in group 2 had back pain even prior to the onset of their perceived work-related insult. This is quite interesting as this defies causality. The only essential

criterion for causality according to Bradford Hill is the presence of a temporal relationship, the cause must precede the effect. However, almost half of the patients in this group already had symptoms prior to the perceived injury. There is therefore also an absence of a temporal relationship and again further refutes the presence of a causal relationship between non-specific back pain and self-perceived work-related injury.

There are many studies in literature assessing the long-term outcomes in patients with work-related injury and spinal fractures but none of these have compared the long-term outcomes between these 2 groups of patients. This comparative contrasting cohort study is therefore unique. Although both groups of patients were comparable in terms of age and sex, the employment and compensation status as well as the visual analogue score for back pain in patients with thoracolumbar fractures was not known. This is due to the limitations of a retrospective study. However, previous studies on patients with thoracolumbar spinal fractures have shown between 50 and 80 % of these patients returning to full-time employment with up to 64 % returning to their previous level of employment and similar numbers reporting minimal or no pain [16–18]. Furthermore, if there were some patients within the fracture group that had poor outcomes due to psychosocial factors such as compensation or failure of return to employment this would further emphasise the clinically significant difference between structural and non-structural injury.

The study also comprised a very selective group of patients to reduce heterogeneity within groups. The purpose was to assess for the presence of a dose–response relationship and consequently, causality. The group of patients used thereby allowed for the comparison at the two extremes of an energy spectrum. Patients with self-perceived work-related injury were recruited from a medico-legal clinic and all were pursuing compensation claims. All patients with actual accidents at work were excluded. The dose of energy involved in this group was minimal and unquantifiable. This may for obvious reasons confound the results as such claims have been shown to result in greater levels of disability. Nevertheless, the highly selective group of patients were only available through a medico-legal clinic setting.

Furthermore, only patients with surgical treatment of their isolated thoracolumbar spinal fractures were included. Conservatively managed patients were excluded. Again the

Table 3 Subgroup analysis of patients with and without previous back pain (mean/SD)

	Age	VAS L	VAS B	ODI	LBO	MSP	MZD
Previous back pain	47/11	4.1/1.6	5.9/2.0	45.6/13.1	20/12.8	8.7/5.3	39.5/8.9
No previous back pain	50/8.9	4.3/2.3	6.1/2.1	40.6/17.4	27/8.6	10/7.6	30/4.8

Table 4 Bradford Hill Criteria of Medical Causality [25]

Dose–response relationship
Temporal relationship
Strength
Plausibility
Consistency
Consideration of alternative explanations
Experiment
Specificity
Coherence

Fig. 3 Dose–response relationship. The dose–response relationship may be linear or more commonly show a sigmoid-shaped curve with a threshold relationship. Before the threshold is reached there is no significant tissue damage with an increasing effect with increasing dose and finally a maximal effect

purpose of this selection bias was to include only those patients with the higher energy injuries at the other extreme of the injury spectrum.

Conclusion

Despite high energy trauma and significant structural damage to the spine, those with high energy injury and thoracolumbar spinal fractures had better spinal outcome scores in all measures (ODI, LBOS, MSP, MZD). We have failed to identify a temporal or a dose–response relationship between structural injury and spinal disability. Uniquely, the disability is greater in the lower energy injury which is unique in trauma care. The reasons for such differences are primarily psychosocial. Self-perceived work-related injury is not a cause of low back pain. There is no causal relationship between structural injury, low back pain and spinal disability (Table 4; Fig. 3).

Conflict of interest None.

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