Reduced active control and passive range at the shoulder increase risk of shoulder pain during inpatient rehabilitation post-stroke: an observational study

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Introduction

Post-stroke shoulder pain is a frequent and disabling condition that has been reported in up to 85% of people who attend rehabilitation (Bender and McKenna 2001, Turner-Stokes and Jackson 2002), and in one-third of stroke survivors in general (Lingdgre et al 2007, Ratnasabapathy et al 2003). Moderate to severe levels of pain are often reported (Lingdgre et al 2007), which can restrict participation in daily activities and rehabilitation, and degrade quality of life (Bender and McKenna 2001, Chae et al 2007). Many factors are proposed to contribute to post-stroke shoulder pain, but these are not well understood. This limits effective management of this disabling condition (Bender and McKenna 2001, Turner-Stokes and Jackson 2002).

Clinicians need a thorough understanding of the factors that increase the risk of post-stroke shoulder pain in order to identify patients at risk and implement strategies to prevent and manage this disabling condition (Nicks et al 2007, Turner-Stokes and Jackson 2002). Recently, the Management Tool for Acute Hemiplegic Shoulder was developed to assess risk during acute hospital settings (Nicks et al 2007). This tool expanded on a best practice model implemented in a rehabilitation setting (Bernhardt and Griffin 2002) and was based on current evidence. The tool focuses on risk factors such as passive range of motion, subluxation, pain, limited shoulder function, and altered muscle tone. While these risk factors are consistent with many outlined in the literature (Bender and McKenna 2001, Lingdgre et al 2007), the Management Tool for Acute Hemiplegic Shoulder omits several factors, such as age, inco-ordination, altered sensation, dyspraxia, side of stroke, body weight, and communication impairment, which may also contribute to risk and influence clinical management (Ratnasabapathy et al 2003). The accuracy of this tool to predict people with stroke who develop shoulder pain has not yet been investigated. It is also likely that relationships exist between proposed risk factors. Models used to assess risk may therefore contain redundant factors and be overly complicated. However, knowledge is limited regarding the multivariate relationships for predictors of shoulder pain to guide the development of risk assessment tools.

Given that existing knowledge about post-stroke shoulder pain has generally been derived from low quality studies (Snels et al 2002) in small biased samples (Ratnasabapathy et al 2003, Turner-Stokes and Jackson 2002), more investigation is needed to identify predictors for this complex, multifactorial problem. Therefore the research questions for this study were:

1. What is the incidence of post-stroke shoulder pain during inpatient rehabilitation?
2. What factors at admission to rehabilitation predict post-stroke shoulder pain during inpatient rehabilitation?

Method

Design

A retrospective audit of medical histories was undertaken to collate the presence of shoulder pain and potential predictors. Information about predictors was obtained from the initial physiotherapy and occupational therapy assessments, which were standardised and involved a comprehensive overview of impairments and activity limitations. Ninety-four histories were randomly selected from a possible 150 histories of all patients with a primary diagnosis of stroke attending inpatient rehabilitation post-stroke. The outcome of interest was shoulder pain. Results: Shoulder pain was present in 23% of patients at admission, and in a total of 35% of patients during inpatient stay. Patients with pain differed significantly (p ≤ 0.04) from those without pain for several factors including age, longer time until rehabilitation admission, impaired movement of the arm (Motor Assessment Scale items), reduced passive range of movement, subluxation, and altered tone and sensation. No differences were found for many factors including neglect, cognitive impairment, side of stroke, and body weight. Logistic regression exploring the association between four predictors (shoulder range, Motor Assessment Scale items, subluxation, and altered sensation) and shoulder pain (outcome of interest) found that shoulder pain was reliably associated with two factors: reduced passive shoulder range (OR 14%, 95% CI 3 to 64), and Motor Assessment Scale Upper Arm item score (OR 64%, 95% CI 43 to 96). The model accurately classified 85% of patients. Conclusion: Shoulder pain is common and occurs early after stroke. Reduced active control and passive range at the shoulder appear to be risk factors for shoulder pain during inpatient rehabilitation post-stroke.

diagnosis of stroke discharged from Austin Health Royal Talbot Rehabilitation Centre between July 2005 and June 2008. Histories were excluded if the length of stay was 6 days or less.

Participants
The 94 histories audited represented 63% of stroke patients admitted for inpatient rehabilitation over a 3-year period. The sample was intended to represent a broad cross-section of people with and without shoulder pain, and included people with cognitive and linguistic impairment who are often not represented in the literature due to inability to provide informed consent (Macrae and Douglas 2008). The sample audited (Table 1) was similar to those not audited for age (mean 59 yr, range 17–80 versus 56 yr, range 18–81) and gender (61% males versus 60%) but had a somewhat longer inpatient stay (mean 48 d, range 7–153 versus 27 d, 1–190).

Outcome measures
The variables collated included a range of impairments, patient characteristics, and stroke-related factors (Table 1), the selection of which was guided by current literature (Lingdgren et al 2007, Ratnasabapathy et al 2003, Turner-Stokes and Jackson 2002). Passive range of shoulder movement was measured using either a goniometer or visual observation. Sensation was measured using a range of clinical assessments including light touch, proprioception, two-point and temperature discrimination. Subluxation was measured by palpation or calipers when the arm was unsupported in sitting. Shoulder pain was deemed present if documented in the weekly therapy reports, ward round, or case conference notes (eg, shoulder pain interfered with dressing or sleeping, therapeutic exercises, or task-related practice, or required analgesia). When possible, information about events (eg, a fall, change in mobility, or use of arm supports) preceding the onset of shoulder pain was collated.

Data analysis
Data were summarised for the sample, and subsamples with and without pain. Data were then analysed using Mann-Whitney (ordinal and interval data that was not normally distributed) and Chi-Square (categoric data) tests to determine how people with pain differed from those without pain. To assist in interpreting the observed differences, odds ratios and mean group differences (with 95% CIs) for all variables were also calculated. Factors that differentiated the group with pain from those without pain were then explored in order to select predictors, and to reduce the likelihood of multicollinearity and overfitting within the multivariate model (Tabachnick and Fiddell 2001). Given the sample size, the multivariate analysis was restricted to a maximum of five predictors. Logistic regression was then conducted to explore factors associated with shoulder pain. The fit of the model was further explored by entering various combinations of predictors into the model. Level of statistical significance was 0.05 for all analyses.

Results

Participants
The participants’ characteristics are summarised in Table 1. Of the 94 participants, 22 (23%) had shoulder pain when admitted to rehabilitation. A further 11 participants developed pain during rehabilitation, leading to a total of 33 (35%) who experienced shoulder pain whilst hospitalised. Pain was reported at various frequencies for the 33 participants with pain (ie, median 33%, range 4% to 100%, of entries per participant). For the 11 participants not admitted with shoulder pain, the first report of pain was at a median of 4 (range 1 to 14) weeks after admission. Several events were noted that might have contributed to the onset of pain in these 11 participants. These included events or poor postures that may have traumatised the shoulder (eg, whilst having investigations such as radiology), altered use of arm supports, change in pattern of motor recruitment for the arm, and a fall.

As no apparent differences were observed between the 22 participants admitted with pain and the 11 who later developed pain for any of the variables collated, the two subgroups were pooled for further analyses. This permitted a comparison between two groups: participants with (n = 33) or without shoulder pain (n = 61). Several factors were observed to differ between those with or without pain (Table 1). Those with pain tended to be younger, took longer to be admitted to rehabilitation after their stroke, and had lower Motor Assessment Scale (Carr et al 1985) scores for the arm. They also tended to have limited passive range of shoulder motion, shoulder subluxation, impaired sensation, and altered muscle tone. For this study, altered muscle tone included both hypotonia and hypertonia (Carr and Shepherd 1998). In contrast, no differences were observed for several variables including the presence of inattention, communication impairment, or area and side of stroke (Table 1).

Prediction of shoulder pain
The four predictors selected for inclusion in logistic regression were Motor Assessment Scale Upper Arm item, passive range of shoulder flexion, subluxation, and altered sensation. These were selected from the 10 variables that differentiated between people with and without pain (Table 1) for several reasons. The predictors focused on primary and secondary impairments following the stroke rather than those relating to hospital processes (eg, days between onset and admission to rehabilitation). When similar variables were moderately related, only one variable was selected. For instance, the Motor Assessment Scale Upper Arm item was selected over the Hand item as it was considered more relevant to the shoulder. Passive range of shoulder flexion was chosen over external rotation as it was considered easier to measure clinically given the reliance upon retrospective data. Although Nicks and colleagues (2007) suggested that less than 160 degrees shoulder flexion was a predictor for post-stroke shoulder pain, we used ≤ 150 degrees as a predictor due to the distribution of shoulder ranges observed. Altered tone was not selected as a predictor as it related to several variables including Motor Assessment Scale scores, subluxation and shoulder range of motion.

Logistic regression using the four predictors identified shoulder pain as reliably associated with two predictors: Motor Assessment Scale Upper Arm item and passive range of shoulder flexion (Box 1). These findings indicate that the odds of experiencing shoulder pain are, on average, 14% greater for people with ≤ 150 degrees passive shoulder flexion relative to those with > 150 degrees. The average odds of shoulder pain increase by 64% for each unit lower on the Motor Assessment Scale Upper Arm item (ie, a score of 5 has a 64% greater chance of shoulder pain than a score of 6). Based on the prediction equation, the mean
odds and probabilities for experiencing shoulder pain are estimated for the range of people with stroke admitted to rehabilitation (Table 2).

Goodness of fit of the model was confirmed statistically, and then further examined by varying the combination of risk factors entered directly into regression. For example, the logistic regression was repeated with an additional 5th variable (eg, days between onset and admission, age, gender, and altered tone). Similarly, different scoring methods were used for the passive range of shoulder flexion variable entered (ie, entering scores in degrees, a continuous variable, or a binary variable, ≤150 degrees or not). After all of these variations, the overall interpretation of the model created remained unchanged, and indicated that Motor Assessment Scale Upper Arm item and passive range of shoulder flexion were associated with post-stroke shoulder pain.
Box 1. Regression coefficients, mean (95% CI) odds ratio of predictors, clinical prediction rule and accuracy of model to predict post-stroke shoulder pain.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Odds ratio (95% CI)</th>
<th>Mean (95% CI) odds ratios for predictors</th>
</tr>
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<tbody>
<tr>
<td>PROM shoulder flexion</td>
<td>0.14 (0.03 to 0.64)</td>
<td>0.14 (0.03 to 0.64)</td>
</tr>
<tr>
<td>MAS Upper Arm item</td>
<td>0.64 (0.43 to 0.96)</td>
<td>0.64 (0.43 to 0.96)</td>
</tr>
</tbody>
</table>

Clinical prediction rule

Odds (shoulder pain) = \( e^{3.73-1.95 (\text{PROM shoulder flexion}) -0.45 (\text{MAS upper arm})} \)

Probability of pain = \( \frac{\text{Odds (shoulder pain)}}{\text{Odds (shoulder pain)} + 1} \)

Nagelkerke \( R^2 = 0.63 \)

Overall accuracy in classifying cases = 85%

Sensitivity = 73%

Specificity = 92%

PROM shoulder flexion = Passive range of motion shoulder flexion (0 = range is ≤ 150 degrees, 1 = range is > 150 degrees), MAS = Motor Assessment Scale

Table 2. Estimated odds and probability of experiencing shoulder pain for scores of Motor Assessment Scale Upper Arm item, and the presence of restricted passive shoulder flexion.

<table>
<thead>
<tr>
<th>MAS Upper Arm score</th>
<th>Odds</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shoulder flexion</td>
<td>&gt; 150 deg ≤ 150 deg</td>
</tr>
<tr>
<td>0</td>
<td>5.9</td>
<td>0.86</td>
</tr>
<tr>
<td>1</td>
<td>3.8</td>
<td>0.79</td>
</tr>
<tr>
<td>2</td>
<td>2.4</td>
<td>0.71</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>0.61</td>
</tr>
<tr>
<td>4</td>
<td>1.0</td>
<td>0.50</td>
</tr>
<tr>
<td>5</td>
<td>0.6</td>
<td>0.38</td>
</tr>
<tr>
<td>6</td>
<td>0.4</td>
<td>0.28</td>
</tr>
</tbody>
</table>

MAS = Motor Assessment Scale

Discussion

The findings from this study support that shoulder pain is a multifactorial problem (Price 2002, Ratnasabapathy et al 2003). People who experienced shoulder pain also had longer periods of hospitalisation, in both the acute and rehabilitation settings. These findings are likely to reflect the severity of stroke and associated complications. Nevertheless, the observations that risk of pain increases with the degree of motor impairment at the shoulder and anecdotal events of trauma that preceded shoulder pain reaffirm that the shoulder is highly vulnerable and requires careful management. Given that one-quarter of patients were admitted to rehabilitation with shoulder pain, strategies to identify risk and prevent shoulder pain should occur early and within the acute hospital setting, as recommended by Nicks and colleagues.

Shoulder pain after stroke is a complex multifactorial phenomenon (Bender and McKenna 2001, Price 2002). We used multivariate analyses to mathematically simplify a set of 10 factors to two predictors of shoulder pain. The multivariate model had a good level of accuracy, and explained 63% of the variance in the dataset. Additional factors, such as age and altered tone, did not enhance the model, which suggests that the fit of the model was good. Nevertheless, given that any model is highly dependent upon its derived dataset (Tabachnick and Fidell 2001), the findings should be replicated in other samples before being recommended for wider use.

Our findings support that shoulder pain post-stroke is heterogeneous in nature (Price 2002). Level of risk and underlying mechanisms are likely to vary according to the type and severity of impairments, and personal (eg, age and premorbid shoulder problems) and environmental factors (eg, trauma) (Ratnasabapathy et al 2003). It therefore seems important to develop clearer diagnostic classifications in order to direct clinical management. Our findings indicate that the Motor Assessment Scale Upper Arm item score may be helpful for this issue. For instance, a score of < 4 indicates a high risk of developing shoulder pain, as proposed in the Management Tool for Acute Hemiplegic Shoulder (Nicks et al 2007). For this group of patients, who are also more likely to have shoulder subluxation, clinical management including use of arm support, electrical stimulation, education, and active motor training to promote shoulder girdle control, as outlined by Nicks and colleagues, seems highly appropriate. However, despite the lower odds, patients admitted with a score of 4 or 5 in our study also had shoulder pain. Physiotherapists would need to employ other approaches to manage these people as different mechanisms for pain, such as shoulder impingement, are likely (Bender and McKenna 2001, Blennerhassett et al 2009).

Despite the observed association with pain, reduced passive range and motor control at the shoulder cannot be considered the cause of post-stroke shoulder pain. Nevertheless, the findings suggest that clinical attention could be directed to improving pain free shoulder joint range, or promoting active shoulder girdle control to align the glenohumeral joint and enable arm elevation. Training should be carefully structured and monitored, given the importance of highly co-ordinated muscular control within the shoulder girdle (Dontalelli 2004), and the potential for impingement, wear and tear, inflammation, and subsequent pain at the shoulder – particularly when the muscles are weak or fatigued, or while performing overhead activities (Ludewig and Reynolds 2009). Education and training
of staff, carers, and patients in how to care for the arm are also warranted (Nicks et al 2007, Turner-Stokes and Jackson 2002), given the vulnerability of a weak shoulder and the events described that may have contributed to the development of shoulder pain.

The sample was representative of stroke patients who undertake rehabilitation in a public setting. The histories were randomly selected, and comprised a broad cross-section of patients, including those with moderate to severe cognitive and communication deficits who are often under-represented in the literature (Macrae and Douglas 2008). Our findings may therefore be generalised to similar cohorts with due considerations to the study’s limitations. The study was a retrospective audit that relied on clinical documentation. However, compliance with documentation was found to be good, and the assessments were conducted in a standardised manner by trained therapists. It was likely that the broad approach taken to audit each history captured the majority of complaints of shoulder pain. For instance, the notes covered the 24-hour period and were written by staff who worked closely with each patient doing tasks requiring shoulder function. Nevertheless, the audit did not collate important aspects such as severity and nature of shoulder pain, nor did it attempt to evaluate management processes or treatment outcome. The observational study supports that post-stroke shoulder pain is common, and more likely to occur in patients who have stiff and weak shoulders.

**Ethics:** The study was approved by the Human Research and Ethics Committee at Austin Health (No H2008/03389).

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**References**


