The effects of position on oxygen saturation in acute stroke: a systematic review

SF Tyson Pennine Acute NHS Trust and University of Manchester, now at Centre for Human Performance and Rehabilitation Research, University of Salford and P Nightingale Pennine Acute NHS Trust, Manchester, UK

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Objective: To investigate the effect of body position on oxygen saturation in the acute stages post stroke.

Design: Systematic review.

Methods: Databases: PREMEDLINE and MEDLINE, Psychinfo, EMBASE, CINAHL, PEDro, all EBM Reviews and Scottish Intercollegiate Guidelines Network (SIGN). Keywords: combinations of cerebrovascular accident/stroke/hemiplegia/cerebrovascular disorders and position or posture or sitting or standing/lying/supine/side lying, with oxygen saturation/oxygen levels/blood gas analysis/hypoxia/sleep apnea syndrome/obstructive sleep disorder/Cheyne Stokes breathing. Limits: English language, human, adults and clinical trials. The quality of relevant papers was independently reviewed using criteria based on the SIGN guidelines for randomized controlled trials and methods described by Rywdik et al.

Results: There were four relevant studies involving 183 patients: three high quality and one poor quality. Heterogeneity in the testing positions, selection criteria, outcome measures and analysis methods prevented meta-analysis. There was strong evidence that body position did not affect oxygen saturation in acute stroke patients without relevant (respiratory) co-morbidities. There was limited evidence that sitting in a chair had a beneficial effect and lying positions had a deleterious effect on oxygen saturation in acute stroke patients with respiratory co-morbidities.

Conclusions: Acute stroke patients without respiratory co-morbidities can adopt any body position, people with respiratory co-morbidities should be positioned as upright as possible.

Introduction

During the acute phase of stroke care a primary aim of treatment is to minimize cerebral damage by avoiding hypoxia. Hypoxia is common post stroke\(^1,2\) and even mild episodes of hypoxia may lessen the potential for neural recovery and outcome.\(^2\) There are several potential causes of hypoxia, including direct stroke-related factors such as weakness of the respiratory muscles on the hemiplegic side or alterations in the central regulation of respiration as well as secondary complications such as aspiration or pulmonary emboli. Premorbid pulmonary and cardiovascular problems may also predispose to the development of hypoxia and body position may affect oxygenation.\(^3\)

Specific positions are often recommended as part of stroke care.\(^4-6\) The aim of these positioning procedures is to promote recovery of the limbs,
prevent contracture and modulate muscle tone. The effect of body position on oxygenation or blood pressure is currently not considered when nurses or therapists decide which position stroke patients should adopt. Current clinical guidelines for stroke care also fail to address this issue. We therefore undertook a systematic review to assess the effect of body position on oxygen saturation in acute stroke patients. This was done with an intention to inform clinical practice in an acute stroke unit that was being set up in our NHS Trust.

### Method

#### Literature search

The literature search was conducted using the following databases: PREMEDLINE and MEDLINE (1966–2004); Psychinfo (1966–2004); EMBASE (1996–2004); CINAHL (1982–2004); PEDro (1980–2004); All EBM Reviews – Cochrane Database of Systematic Reviews, Cochrane Controlled Trials Register, Central Register of Controlled Trials, DARE (up to first quarter of 2004) and Scottish Intercollegiate Guidelines Network (www.sign.ac.uk). The search strategy for the MEDLINE database is shown in Appendix 1, others are available from the authors. The reference lists of relevant papers identified from the database searches were also hand searched. Combinations of the following keywords were used: cerebrovascular accident/stroke/hemiplegia and position/posture/sitting/standing/lying/supine/side lying with oxygen saturation/oxygen levels/blood gas analysis/hypoxia/sleep apnea syndrome/obstructive sleep disorder/Cheyne Stokes breathing. The limits were: adult, human, English language and controlled trials. There were no limits on the type of study or any minimal quality criteria for inclusion.

#### Evaluation of methodological quality

The searches were performed independently by both authors. Relevant articles were highlighted and their reference lists hand searched for further relevant articles. The completed lists of references were compared. Any differences in results were resolved by discussion. Each relevant paper was reviewed independently by both authors. Information about the quality of the papers was gathered using criteria based on those recommended for randomized controlled trials by the Scottish Intercollegiate Guidelines Network (Table 1) and tables of evidence were drawn up. The strength of this evidence was evaluated using the methods described by Rydwik et al. There were 10 quality criteria; one point was allocated for each criterion that was addressed, giving a total score of 10. These scores were then classified; a score of 0–3 was classified as a poor-quality study, a score of 4–6 was classified as a moderate-quality study and a score of 7+ was classified as a high-quality study. The strength of the evidence was defined as:

- **Strong evidence**: Concordant results in more than half of the high-quality studies.
- **Moderate evidence**: Concordant results in one high-quality RCT and one or more moderate- or low-quality studies, or if there were concordant results in more than half of the moderate quality RCTs.
- **Limited or contradictory evidence**: One RCT with high-, moderate- or low-quality or contradictory evidence from several RCTs.
- **No evidence**: No RCTs found.

#### Table 1

**Criteria for evaluation of randomized controlled trials recommended by the Scottish Intercollegiate Guidelines Network**

1. Does the study address appropriate and clearly focused questions?
2. Was the assignment of subjects to treatment groups randomized?
3. Was an adequate concealment method used?
4. Were subjects and investigators kept blind about treatment allocation?
5. Were the treatment and control groups similar at the start of the trial?
6. Apart from the treatment under investigation were the groups treated equally?
7. Are all relevant outcomes measured in a standard, valid and reliable way?
8. What percentage of the individuals or clusters recruited into the study is included in the analysis?
9. Were all the subjects analysed in the groups to which they were randomly allocated?
10. Are the results homogeneous between sites?

*a Question 10 was not relevant to the studies in this review so another question was substituted: Was the study adequately powered. Was a power calculation used to determine the sample size?*
Relevant papers were independently evaluated by each of the authors and results compared. Discussion and negotiation resolved any differences. A third reviewer was available to arbitrate on unresolved issues but this was unnecessary.

Results and discussion

Quality of the papers/methodological details

Four relevant papers involving 183 stroke subjects were identified. The tables of evidence and quality criteria scores for the papers are shown in Tables 2 and 3. Three studies were of high quality, all of which scored 8/10, and one was of poor quality, which scored 3/10. Even in this small collection of papers there was a high degree of heterogeneity between the studies regarding the positions tested, the measurement variables, the selection criteria and the method of analysis which prevented meta-analysis (Table 2a).

Methodological quality

The aim of all four studies was to assess the effects of body position on oxygenation in acute strokes. All the studies were controlled trials using a paired design so the subjects acted as their own controls; the control data was from a reference position rather than a separate group of subjects. This meant that the studies scored highly on criteria surrounding equality between groups as the treatment and control groups were the same people, it is assumed (but not explicitly stated) that they were equal. Two studies included complete data sets, but in the other two studies only about half the subjects completed all the testing positions. This was because ‘sitting out in a chair’ was included as one of the test positions and not all subjects were able to do this because their sitting balance was too poor for them to sit out safely. The missing subjects were accounted for and their data were included in the analysis – indicating an intention-to-treat analysis, although neither paper stated explicitly that this was done.

Although all the studies used a paired design, not all used a paired analysis. Three studies used an unpaired group analysis (repeated measures ANOVA, ANOVA and two-way ANOVA respectively) and found nonsignificant differences. Rowat et al. used a paired analysis (paired ANOVA) and found significant differences. A paired analysis is more likely to find differences that reach significant levels than an unpaired analysis, especially (as in this case) if there is high intersubject variability. It is therefore possible that the confounding results found between the studies were due, at least in part, to the different methods of analysis.

All the studies except that by Elizabeth et al. were randomized in that the order in which the positions were tested was randomized, rather than the allocation of subjects. Elizabeth et al. used a set testing order for the different positions. None of the studies were blinded and it is hard to devise a way in which either subjects or tester could be blinded to the subjects’ position but none of the studies used a blind assessor/analyst.

The number of subjects were small (n = 106–129). Two studies included power calculations in their methodology and found that 12 and 30 subjects were needed per testing position respectively. Rowat et al. calculated for a power of 0.95 at 3% standard deviation, while Chatterton et al. calculated for 0.88 power with a 2% standard deviation, which would account for the differences in sample sizes. The other two studies did not include a power calculation, had a nonsignificant result and were under-powered. All the studies recruited people in the acute stages post stroke. One recruited subjects within the first seven days (median time since stroke was three days and 60% were seen within 72 h of onset) and the others recruited within 72 h. Only one study recruited from more than one centre.

Sources of heterogeneity

Outcome measures

In three studies pulse oximetry was used to measure oxygen saturation and hypoxia, however the criteria to indicate a hypoxic event differed between studies. Chatterton et al. used frequency of oxygen saturation of less than 90% for 3 min, Rowat et al. used oxygen saturation of less than 90% for 2 min while Elizabeth et al. used any period with a oxygen saturation at less than 90% (Table 2a), which prevented comparison between the studies. The remaining study used blood gas analysis.
<table>
<thead>
<tr>
<th>Source</th>
<th>Design and subjects</th>
<th>Exclusion criteria</th>
<th>Analysis</th>
<th>Outcome measure</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chatterton et al. 2000&lt;sup&gt;13&lt;/sup&gt;</td>
<td>Within-subject RCT acute strokes (within 72 h) n = 24, 2 centres</td>
<td>Previous or current condition which may predispose to hypoxic events or not for active treatment</td>
<td>Repeated measures ANOVA</td>
<td>Respiratory rate @ 5 and 55 min, Mean SaO&lt;sub&gt;2&lt;/sub&gt;, no. of desaturation episodes (&lt;90% for 3 min)</td>
<td>Sitting in chair, sitting up in bed (backrest @ 70'), high side-lying (45') on weak and sound side, 1 h in each position</td>
</tr>
<tr>
<td>Rowat et al. 2001&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Within-subject RCT, acute strokes (within 7 days, median time = 72 h) n = 129, 1 centre</td>
<td>Subarachnoid haemorrhage, uncooperative, able to walk or change position unaided</td>
<td>ANOVAs for paired data and Student's post-hoc tests</td>
<td>Continuous monitoring of SaO&lt;sub&gt;2&lt;/sub&gt;, and heart rate for 10 min → mean values. Hypoxia = SaO&lt;sub&gt;2&lt;/sub&gt; &lt; 90% for 2 min</td>
<td>Sitting in chair, propped in bed, weak and sound side-lying, supine. 10 min in each position</td>
</tr>
<tr>
<td>Pang et al. 1988&lt;sup&gt;16&lt;/sup&gt;</td>
<td>Within-subject RCT, acute (≤ 48 h) dense (Oxford scale ≤ 2) strokes, n = 20, 1 centre</td>
<td>Previous lung disease, heart failure, or stroke; brainstem involvement</td>
<td>Two-way ANOVA</td>
<td>pH and PO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Sitting up, supine, side-lying on weak and sound side. 20 min in each position</td>
</tr>
<tr>
<td>Elizabeth et al. 1993&lt;sup&gt;16&lt;/sup&gt;</td>
<td>Controlled clinical trial, dense (MRC grade &lt; 2 weakness in limbs), acute strokes (within 48 h), n = 10, 1 centre plus 10 acute medical controls</td>
<td>Previous stroke, irregular breathing, previous respiratory disease or cardiac failure</td>
<td>ANOVA</td>
<td>Mean SaO&lt;sub&gt;2&lt;/sub&gt;, lowest SaO&lt;sub&gt;2&lt;/sub&gt;, and time &lt; 90% SaO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Lying (supine or side-lying), propped up in bed (45') in set order. 30 min→1 h in each position</td>
</tr>
</tbody>
</table>

RCT, randomized controlled trial; ANOVA, analysis of variance; HR, heart rate.
<table>
<thead>
<tr>
<th>Source</th>
<th>Results</th>
<th>Conclusion</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chatterton <em>et al.</em> 2000&lt;sup&gt;13&lt;/sup&gt;</td>
<td>No differences in any outcome measure for any position. No relationship between ( SaO_2 ), weakness, stroke severity or level of consciousness</td>
<td>Sitting or high side-lying does not affect ( O_2 ) saturation in strokes with no relevant co-morbidities</td>
<td></td>
</tr>
<tr>
<td>Rowat <em>et al.</em> 2001&lt;sup&gt;14&lt;/sup&gt;</td>
<td>Higher ( SaO_2 ) and HR when sitting in a chair than other positions for those who could sit out. No difference between lying on weak or sound side, but lying on left side ( \rightarrow ) greater ( \downarrow ) ( SaO_2 ) and HR than right side-lying. Desaturation most likely in left side-lying, severe strokes, right hemiplegia and co-morbid chest disease. Hypoxia-inducing positions = slumped sitting in bed and left side-lying</td>
<td>Sitting in a chair is best if the patient can do this safely. Avoid left side-lying for right hemiplegics</td>
<td>22/129 could lie only. Only 65/129 could sit out in chair. Only 61/129 could manage all 5 positions. There were more than enough subjects for each position to satisfy the power calculation (30 per position)</td>
</tr>
<tr>
<td>Pang <em>et al.</em> 1988&lt;sup&gt;15&lt;/sup&gt;</td>
<td>No difference found in any position</td>
<td>No differences in dense acute strokes with no relevant co-morbidities</td>
<td>Not clear whether sitting position was in bed or a chair</td>
</tr>
<tr>
<td>Elizabeth <em>et al.</em> 1993&lt;sup&gt;16&lt;/sup&gt;</td>
<td>No difference in any outcome measure for any position</td>
<td>No differences found</td>
<td>Preset order of testing the positions, not randomized</td>
</tr>
</tbody>
</table>

HR, heart rate.
Testing positions

The positions used varied. Lying supine and/or lying on either side, high side-lying (lying on the side and propped up at 45°), sitting up in bed and sitting out in a chair were all measured but no single study measured all positions. In most cases the positions used were clearly explained but Pang et al.\(^\text{15}\) did not describe the sitting position in detail so it is not clear whether the subjects sat out in a chair, over the edge of the bed or upright in bed. The duration for which the subjects assumed each position also varied from 10 min\(^\text{14}\) to 1 h\(^\text{13}\) in each position. Only Rowat et al.\(^\text{14}\) gave a rationale for the length of time for which each position was adopted (10 min). There was no difference in result with the different times; the longer duration was not more likely to produce a significant result than the shorter durations.

Selection criteria

Three studies\(^\text{13,15,16}\) excluded people with relevant co-morbidities (pre-existing cardiac and/or respiratory disease or previous stroke) and found that position did not affect oxygen saturations. The other study\(^\text{14}\) included a generalizable clinical population, by recruiting all types of acute stroke patients with any previous medical history and found that sitting upright had a beneficial effect on oxygen saturation. They also found that the presence of respiratory problems was the only factor significantly associated with hypoxia on change of position. This suggests that (a) the difference in selection criteria could account for the conflicting results and (b) a positional effect on oxygen saturations may be limited to patients with co-morbid respiratory and/or cardiac problems.

Study findings

There was strong evidence from two high-quality studies\(^\text{13,15}\) that different sitting or lying positions had no effect on oxygen saturation in acute stroke patients with no relevant co-morbidities. This was supported by Rowat et al.’s\(^\text{14}\) finding that breathing difficulties were the only factor significantly associated with posture related desaturation. There was further strong evidence (three high-quality\(^\text{13–15}\) studies and one poor-quality\(^\text{16}\) study) that different lying position
(supine, lying on the weak or sound side) had no effect on oxygen saturations.

There was limited evidence from one high-quality study\textsuperscript{14} that for acute stroke patients, particularly those with respiratory co-morbidities, sitting in a chair had a beneficial effect and lying positions had a deleterious effect on oxygen saturation.

Discussion

Methodological considerations

The literature searches for this study were repeated several times by two independent searchers and hand searches were made of the reference lists of the all the identified articles in an attempt to identify all the relevant studies. However one can never be certain that all the relevant articles have been found.

The studies in this review all used a paired design with the subject acting as their own control. This is an optimal design for the research question, when there is a high degree of variability between subjects and the effect of the intervention on a nonsubject control group is not relevant. However, despite extensive searches we were unable to identify any valid, pre-published criteria specifically for this type of design. Consequently we used the quality criteria designed by the Scottish InterCollegiate Guideline Network\textsuperscript{11} for ‘traditional’ randomized control trials with separate treatment and control groups and so some bias that inflated the scores may have been introduced, especially as the studies automatically scored highly for the criteria which considered equality of treatment between groups, as the treatment and control groups were the same people. Additionally, no weight was given to the importance of the criterion. Consequently the same score was given for important criteria such as randomization or blinding, as for relatively minor criteria such as whether there was a clear aim or power calculation. This may have introduced bias, particularly to inflate the scores of lower quality studies. We categorized the studies into three levels of methodological quality using the methods described by Rydwik et al.\textsuperscript{12} The choice of three categories is controversial and should be treated with some caution. It is not really known whether a score of three (classified as ‘poor quality’) indicated a study whose results were clearly less robust than a study with a score of four (classified as moderate quality). However categorizing the results of the review does enable the results of the review to be applied in clinical practice in a meaningful way, but one should be aware that the classification, although logical, was arbitrary.

None of the studies were blinded. Although it would not be possible to blind either the subject or tester to the subjects’ position, future studies with a blind assessor/analyst would minimize this potential bias.

This systematic review was hampered by the heterogeneity of the outcome measures used. Although all the studies used oxygen saturation as the main outcome measure, they all used different definitions of hypoxia, so meta-analysis was not possible. No definition of hypoxia emerged as preferable or most clinically meaningful but 10% desaturation was most frequently used (although the duration of desaturation that was considered clinically significant varied from immediate, to 3 min). The point at which deoxygenation should be treated has not been defined.\textsuperscript{9,10,17–19} The American College of Chest Physicians and the National Heart and Lung Institute recommend supplementary oxygen therapy should be administered if saturation levels fall below 90%, but others have recommended 95% saturation.\textsuperscript{3} Further study is needed to identify the most clinically important definition of hypoxia, before studies can investigate the effectiveness of interventions (such as consistent positioning or supplementary oxygen) to prevent or treat hypoxia post stroke.

Clinical messages

- There is strong evidence that for stroke patients who do not have hypoxia or relevant co-morbidities, oxygen saturation is not affected by body position.
- There is limited evidence that stroke patients who suffer from, or who are at risk of hypoxia, should be positioned as upright as possible and sit out in a chair if they are safe to do so. Lying positions (supine or side-lying) should be avoided.
The different selection criteria caused further heterogeneity. Studies that excluded subjects with relevant co-morbidities (cardiac and/or respiratory disease) showed that body position did not affect oxygen saturation, but a single high-quality study\textsuperscript{14} showed positional changes in oxygenation in people with respiratory co-morbidities. Further comprehensive studies are needed which include all co-morbidities and all severity of stroke to establish the influence of cardiac and respiratory disease and severity of stroke. They also need to use a paired design and analysis to deal with the high degree of interindividual variability found in the subject population. Finally, further work is needed to investigate the long-term effects of consistently positioning patients to prevent post-stroke hypoxia.

References

### Appendix 1 – Search history for MEDLINE database 1966–2004

<table>
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<th>Step</th>
<th>Query</th>
<th>Results</th>
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<td>1)</td>
<td>(stroke or cerebrovascular accident or hemiplegia or cerebrovascular disorders).mp. [mp = title, original title, abstract, name of substance, mesh subject heading]</td>
<td>90,844</td>
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<td>limit 1 to (human and english language)</td>
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<tr>
<td>3)</td>
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<td>80,207</td>
</tr>
<tr>
<td>4)</td>
<td>limit 3 to (human and english language)</td>
<td>54,859</td>
</tr>
<tr>
<td>5)</td>
<td>2 and 4</td>
<td>1,773</td>
</tr>
<tr>
<td>6)</td>
<td>limit 5 to (human and english language and (adult &lt; 19 to 44 years&gt; or middle age &lt; 45 to 64 years&gt; or middle aged &lt; 45 plus years&gt; or aging &lt; 65 to 79 years&gt; or “all aged &lt; 65 and over &gt;” or “aged &lt; 80 and over &gt; ”) and (clinical trial or clinical trial, phase i or clinical trial, phase ii or clinical trial, phase iii or clinical trial, phase iv or controlled clinical trial or randomized controlled trial))</td>
<td>287</td>
</tr>
<tr>
<td>7)</td>
<td>from 6 keep 77, 96</td>
<td>2</td>
</tr>
<tr>
<td>8)</td>
<td>(oxygen saturation or oxygen levels or blood gas analysis or hypoxia or sleep apnea syndrome or obstructive sleep disorder or Cheyne Stokes).mp. [mp = title, original title, abstract, name of substance, mesh subject heading]</td>
<td>62,343</td>
</tr>
<tr>
<td>9)</td>
<td>limit 8 to (human and english language)</td>
<td>27,469</td>
</tr>
<tr>
<td>10)</td>
<td>2 and 9</td>
<td>576</td>
</tr>
<tr>
<td>11)</td>
<td>limit 10 to (human and english language and (adult &lt; 19 to 44 years&gt; or middle age &lt; 45 to 64 years&gt; or middle aged &lt; 45 plus years&gt; or aging &lt; 65 to 79 years&gt; or “all aged &lt; 65 and over &gt;” or “aged &lt; 80 and over &gt; ”) and (clinical trial or clinical trial, phase i or clinical trial, phase ii or clinical trial, phase iii or clinical trial, phase iv or controlled clinical trial or randomized controlled trial))</td>
<td>61</td>
</tr>
<tr>
<td>12)</td>
<td>from 11 keep 24, 30</td>
<td>2</td>
</tr>
<tr>
<td>13)</td>
<td>2 and 4 and 11</td>
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<tr>
<td>14)</td>
<td>limit 13 to (human and english language and adult &lt; 19 plus years&gt; and (clinical trial or clinical trial, phase i or clinical trial, phase ii or clinical trial, phase iii or clinical trial, phase iv or controlled clinical trial or randomized controlled trial))</td>
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</tr>
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<td>15)</td>
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