The influence of positioning upon cerebral oxygenation after acute stroke: a pilot study

Sir—Passive postural changes may have an effect on a number of physiological parameters after stroke [1]. For example, standing, sitting or even elevating the head after stroke might reduce cerebral blood flow due to poor collateral circulation and an inability to regulate and augment cerebral blood flow in ischaemic regions of the brain [2–5]. Optimal positioning for patients in the acute stage after stroke is still unknown [6–8]. Variation in clinical practice is evident in the literature [5–9] and has been observed [10]. This variation could be because of the paucity of experimental findings to inform a scientific rationale for positioning early after stroke. For example, traditionally, people who have suffered a large hemispheric stroke have been managed with head elevation between 30° and 45° [5], a practice generalised from clinical experience with head trauma patients despite differences in pathophysiology [11].

There is some experimental evidence that positional change may alter cerebral haemodynamics after stroke [12, 13]; but, there is disagreement on how this is changed early after the ictus [12–15]. Moreover, the natural history of autoregulation following stroke is unclear [16]. At present, there is a paucity of evidence to support or refute the possibility that in some people the vulnerable ischaemic penumbra might be at risk from a reduction in cerebral blood flow mediated through positional changes after stroke [1].

To be relevant clinically, cerebral oxygenation needs to be measured in relation to changes in posture. It also needs to be measured in real time at the bedside to enable appropriate clinical decisions about positioning. The relatively new technology of near infrared spectroscopy (NIRS), a minimally invasive technique, offers the possibility of making such measurements [17]. The aim of this pilot study is to explore whether changes in position, involving different placements of the head and upper body in relation to gravity, in the first week after a middle cerebral artery cortical ischaemic stroke produce changes in cerebral oxygenation in the region of the arterial territory.

Methods

A replicated single case study design was used with the phase sequence ABACA (details in procedure section below). The study was approved by the Local Research Ethics Committee and participants provided either written informed consent or, if that was not possible, assent was provided by their next-of-kin.

Participants were adults who had suffered a middle cerebral artery cortical ischaemic stroke, confirmed by computer tomography (CT) no more than 7 days prior to testing. Exclusion criteria were: a previous stroke in the same division of the ipsilesional medial cerebral artery (MCA) territory; critical illness (peripheral oxygen saturations <90% on air, pulse >100 beats per min, systolic BP <90 mmHg, Glasgow Coma Score <10); inability to follow one-stage command; and, inability to sit upright on the edge of a bed with support from one person.

Participants were seated in a multi-position chair (see instrumentation below) in a quiet room adjacent to the acute stroke unit. Two optodes were placed bihemispherically on their scalp with a 4 or 5 cm distance between the receiving and emitting probes over each hemisphere. Positional accuracy of the optodes was achieved through superficial scalp marking over the ischaemic lesion using laser guidance at CT scanning and mirrored over the opposite hemisphere. An electronic topical recorder was used to record peripheral oxygen saturations, pulse and blood pressure at 2-min intervals. This ensured systematic measurements [17]. The aim of this pilot study is to explore whether changes in position, involving different placements of the head and upper body in relation to gravity, in the first week after a middle cerebral artery cortical ischaemic stroke produce changes in cerebral oxygenation in the region of the arterial territory.

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1. **A phase—supine lying.**
2. **B phase—45° back-rest/seat with legs raised up straight as if lying propped up in bed.**
3. **A phase—supine lying.**
4. **C phase—sitting upright with hips, knees and ankles at 90° as if sitting in a chair.**
5. **A phase—supine lying.**

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After an initialisation phase of 15 min supine, each postural challenge lasted up to 15 min depending upon subjects’ comfort in the position.

A two-channel ‘NIRO 300’ (Hamamatsu Photonics K.K., Japan) was used to record data on cerebral oxygenation at 2 Hz. The ‘NIRO 300’ produces infra-red light via an emitting probe which directs the photons perpendicular to the tissue surface. A receiving probe detects the incident and transmitted light intensities from the tissue. Inbuilt computational software utilising algorithms generated from the modified Beer–Lambert law display and record relative changes in the concentration of oxygenated haemoglobin (\(\Delta[HbO_2]\)), deoxygenated haemoglobin (\(\Delta[Hb]\)) and oxidised cytochrome oxidase (\(\Delta[CtOx]\)) over the period of study. Using the technique of spatially resolved spectroscopy (SPS), a measure of absolute tissue oxygen saturation, the tissue oxygenation index (TOI) can be generated. TOI is the ratio of oxygenated ([HbO2]) to total tissue haemoglobin concentrations ([HbT]) [17].

The multi-position chair used for testing had an adjustable back- and leg-rest enabling any position between lying supine and sitting with hips, knees and ankles at 90°. Position was controlled by the researcher through a hand-held electronic device.

The descriptive data collected for participants were: age, gender and the National Institute of Health Stroke Scale (NIHSS) [18].

The primary outcome was bihemispheric NIRS monitored TOI (i.e. the ratio of oxygenated ([HbO2]) to total tissue HbT).

The probability of serial dependency in 1-min sets of data, collected immediately before and after each posture change, was tested using the autocorrelation coefficient and Bartlett’s test. All data sets were significantly autocorrelated \(r>0.183\), range 0.285–0.991. Statistical comparison of phases was therefore invalid and data were plotted and then interpreted by visual inspection for trend and level.

Results

Seven people who met the study criteria were included. In summary, their mean age was 70.71 years (range 58–81 years); five were male and the median time for measurement after stroke was 5 days (range 4–7). Subject characteristics are presented in Appendix 1 in the supplementary data on the journal’s website. Two patients (subjects 2 and 3) had their anti-hypertensive medication continued after stroke onset and one patient (subject 2) had occlusion of the ipsilateral internal carotid artery. One patient (subject 2) exhibited orthostatic hypotension (defined as a drop in systolic blood pressure \(\geq 20\) mmHg) on postural challenges. There were no changes noted in heart rate or oxygen saturations.

Visual inspection of the plotted data indicated that six of the seven patients (subjects 1, 2, 3, 5, 6, 7) demonstrated changes in TOI between supine and sitting up positions. In these patients, the pattern displayed a maximum value of TOI in the supine position and a reduction of TOI on sitting up in the affected middle cerebral artery territory (Figures 1 and 2). There were also similar changes in TOI observed in the contra-lateral lobe (subjects 1, 2, 3, 6, 7); but these were less marked. In one patient (subject 5), TOI was maximal in the upright position and reduced in the supine position in the contra-lateral lobe only.

Discussion

This is the first study to examine changes in cerebral oxygenation in relation to positioning during the acute phase of ischaemic stroke using NIRS, and has demonstrated that changes in body position in the first week after a MCA cortical ischaemic stroke might produce changes in cerebral oxygenation in the lesion site. An important observation was that cortical cerebral oxygenation in the infarcted territory, as measured by TOI, was consistently lowest during orthostatic postural challenges and maximal in supine positions in the majority of subjects, although there was no difference in peripheral oxygen saturations. Orthostatic stress during the acute phase of stroke might impair the maintenance of cortical oxygenation once cerebral autoregulation has been breached, placing the ischaemic penumbra at further risk. Reasons for a reduction in cerebral oxygenation during orthostatic challenges might have included a reduction of cerebral blood flow through hydrostatic changes; direct blood pressure changes below the autoregulation range in patients with occlusive carotid disease [12]; and increased oxygen extraction by the brain in an attempt to maintain oxygenation during a period of hypoperfusion or redistribution of blood to other areas to support ‘at risk’ tissue [19, 20]. The presence of hypertension, use of anti-hypertensive medication and associated carotid disease may also have contributed to some of the changes observed; however, similar findings were also observed in healthy elderly persons subjected to postural challenges in the absence of decreases in orthostatic BP [20]. Likewise, Panayiotou and colleagues demonstrated no significant differences in orthostatic BP levels acutely comparing stroke patients on and off anti-hypertensive medication [21]. Similar trends of TOI changes were also observed in the contra-lateral hemispheres thus supporting age-related changes in the decline in cerebral oxygenation during orthostatic postural challenges [20], although the magnitude of changes on visual inspection appeared less marked.

The study has its limitations. The numbers of case studies are small and coupled with the heterogeneity of the characteristics of the stroke group may explain some of the inter-individual response variation. In addition, continuous blood pressure monitoring was not used and therefore beat to beat haemodynamic measures in association with TOI were not calculated. NIRS can only measure cerebral oxygenation and cerebral blood flow indirectly at the cortical level and not at the subcortical level where transcranial Doppler may be more informative.
Figure 1. NIRS trace demonstrating value of TOI in supine and on sitting up in affected hemisphere and non-affected hemisphere. Index of phases: A2 = last minute of supine lying, B1 = first minute of 45° sitting with legs up, B2 = last minute of 45° sitting up with legs up, A1 = first minute of supine lying, A2 = last minute of supine lying, C1 = first minute of 90° sitting with legs down, C2 = last minute of 90° sitting with legs down, A1 = first minute of supine lying.
Patients who suffer an ischaemic stroke form a heterogeneous group. No single strategy regarding positioning in the acute setting will apply to all. NIRS does offer the opportunity to study individual patient’s response to orthostatic postural sitting challenge in real time after acute stroke. This may lend support to understand the physiological changes that occur acutely after stroke and also how this changes with positioning. However, the observed changes in cerebral oxygenation after passive postural challenges may not be transferable to active postural challenges as part of an early mobilisation strategy [22, 23]. Studies examining the relationship between the effects of positioning on cerebral cortical oxygenation and outcome in a wider range of patients such as those with carotid occlusion and different stroke subtypes are required.

**Key points**

- NIRS offers measurement of cerebral oxygenation in real time at the bedside post stroke.
- Changes in cerebral oxygenation can occur between supine and upright positioning after stroke.
Future studies should address the effects of positioning on cerebral oxygenation and outcome after stroke.

Supplementary data

Supplementary data for this article are available at Age and Ageing online.

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References


Positional vertigo in a falls service

SIR—Dizziness is one of the commonest symptoms described by older people [1] and is associated with balance disorders, functional decline, reduction in quality of life and falls [2–4]. At least 50% of older people with dizziness complain of two different dizzy symptoms; the most common being a gait disorder (a feeling of disequilibrium on walking) [5], and the other arising from the cardiovascular and peripheral vestibular systems [6]. Dizziness and balance disorders in older people are common presenting symptoms at Falls clinics.

‘Positional vertigo’ (brief episodes of vertigo with nystagmus provoked by changes in head position) is one of the most common symptoms [7] presented to an ear, nose and throat (ENT) service. Benign paroxysmal positional vertigo (BPPV) accounts for the great majority of these cases and is caused by peripheral vestibular rather than central pathology [8]. Posterior canal benign paroxysmal positional vertigo (p-BPPV) is the commonest type of positional vertigo seen and is treatable [9].

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