Cerebral emboli and depressive symptoms in dementia

NITIN PURANDARE, RICHARD C. OUDE VOSHAAR, JAYNE HARDICRE, JANE BYRNE, CHARLES MCCOLLUM and ALISTAIR BURNS

Background The vascular depression hypothesis and our recent findings of increased frequency of spontaneous cerebral emboli in dementia suggest that such emboli may be involved in the causation of depressive symptoms in dementia.

Aims To evaluate the association between spontaneous cerebral emboli and depressive symptoms in Alzheimer’s disease and vascular dementia.

Method In a cohort of 142 patients with dementia (72 with Alzheimer’s disease and 70 with vascular dementia), the association between spontaneous cerebral emboli and clinically relevant depressive symptoms was examined using multiple logistic regression analyses.

Results Spontaneous cerebral emboli were significantly more frequent in the patients with clinically relevant depressive symptoms (66 vs. 37%, P=0.03). After adjustment for age, gender, Mini-Mental State Examination score, type of dementia and significant cardiovascular risk factors, the relationship remained significant (OR = 3.47, 95% CI 1.10–10.97).

Conclusions Spontaneous cerebral emboli are associated with clinically relevant depressive symptoms in dementia, and further research is needed to explore the nature of this relationship.

Declaration of interest None. Funding detailed in Acknowledgements.

Depressive symptoms

Depressive symptoms were assessed at an interview with carers using the Neuro-psychiatric Inventory (NPI; Cummings et al., 1994), which rates depressive symptoms and 11 other non-cognitive symptoms in the patient over the previous month. If the screening question is answered positively, the severity is classified into ‘mild’, ‘moderate’ or ‘severe’ (score 1–3) and the frequency into ‘less than once a week’, ‘once a week’, ‘most days, but not every day’ and ‘every day’ (score 1–4). The NPI symptom score is calculated by multiplying the scores for severity and frequency, which gives a range of 1–12 if a symptom is present and a score of 0 if a symptom is absent. A score of 4 or more on the depressive symptom sub-scale (mild symptoms occurring every day, or moderate to severe symptoms occurring at least once a week) was used to identify clinically relevant depressive symptoms (Aalten et al., 2005; Holthoff et al., 2005).

Cerebral emboli

The presence of spontaneous cerebral emboli was investigated independently in the Vascular Studies Unit at South Manchester University Hospital by technologists who did not have access to information about dementia type or details of the patients’ symptoms. The methods, including the key technical parameters, have been described previously (Ringelstein et al., 1998; Purandare et al., 2006). Briefly, continuous transcranial Doppler insonation of the middle cerebral arteries via the trans-temporal windows for 1 h was used to detect the emboli. The output was recorded on digital tape for subsequent analysis by a vascular technologist, masked to patient identity. Patients were observed during each session for any movement so that artefacts could be identified. Emboli were defined using international consensus

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Patients

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criteria, which specify that embolic signals should be transient (lasting less than 300 ms), at least 3 dB higher than the background flow signal, unidirectional within the Doppler spectrum, and accompanied by an audible ‘snap’, ‘chirp’ or ‘moan’ (Consensus Committee of the Ninth International Cerebral Hemodynamic Symposium, 1995). Detection of one or more embolic signals constituted a positive finding.

**Cardiovascular risk factors**
The severity of carotid disease was imaged using colour duplex ultrasound (Ultramark 9; Advanced Technology Laboratories, Inc., Washington, DC, USA). The peak systolic velocity in the internal carotid arteries was used to calculate the degree of stenosis, using established criteria (Sidhu & Allen, 1997). Blood pressure was measured manually after a 5 min rest. Pulse pressure, calculated as the difference between the systolic and diastolic blood pressures, is related to arterial stiffness and as such was used as a measure of atherosclerosis (Van Popple et al, 2001). A blood sample was taken to assess lipid profile and apolipoprotein E genotype. Data on the following cardiovascular risk factors were collected at interview with patients and their caregivers, and by reviewing case notes: smoking status (current/former/non); alcohol consumption per week over 14 units (women) or 21 units (men); drug history; and history of myocardial infarction, angina, stroke, transient ischaemic attacks, hypertension, hypercholesterolaemia or diabetes.

**Statistical analyses**
We used chi-squared statistics or Fisher’s exact test to determine the univariate relationship between the NPI depression scores (≥4) and the presence of spontaneous cerebral emboli. To control for potential confounders we performed multiple logistic regression analyses entering the dichotomised NPI depression scores as the dependent variable and the presence or absence of emboli as the independent variable. The analysis was repeated initially without controlling for the effect of potential confounding variables, and secondarily by using age, gender, type of dementia and level of cognitive functioning (MMSE score) as independent variables. Thereafter, we also adjusted for all cardiovascular risk factors that were univariately associated with depressive symptoms in our sample at the 15% level. The level of significance in the final model was set at $P < 0.05$ (two-tailed).

**RESULTS**

**Participants**
Of the original cohort of 170 patients with dementia (Purandare et al, 2006), 28 were excluded because NPI data were not available ($n=25$) or no reliable transtemporal window for detecting cerebral emboli was found ($n=3$). The excluded patients did not differ significantly from those included with respect to age, gender, diagnosis or MMSE score. Of the 142 patients included, 72 had Alzheimer’s disease (63 probable, 9 possible disease) and 70 had vascular dementia (45 probable, 25 possible). The patients’ average age was 76.6 (s.d.=7.0) years and 73 (51%) were women. The mean MMSE score was 21.5 (s.d.=4.8). The Alzheimer’s disease and vascular dementia groups were similar with regard to age, gender and MMSE scores.

**Depressive symptoms and cerebral emboli**
Spontaneous cerebral emboli were detected in 29 (40%) patients with Alzheimer’s disease and 28 (40%) patients with vascular dementia (Pearson $\chi^2$, $P=0.97$). The depression screening question suggested the possibility of depressive symptoms in 62 patients (44% of the sample), of whom 15 (11%) patients scored 4 or higher on the depression sub-scale of the NPI; 9 (13%) of the 72 patients with Alzheimer’s disease and 6 (9%) of the 70 patients with vascular dementia (Pearson $\chi^2$, $P=0.45$). The prevalence of this clinically relevant depression was significantly higher among patients with emboli (Table I; Pearson $\chi^2$, $P=0.027$).

**Multivariate analyses**
The groups with Alzheimer’s disease and vascular dementia were combined in the multivariate analyses, as neither the prevalence of emboli nor depressive symptoms differed significantly between the two types of dementia. Logistic regression analysis adjusted for age, gender, diagnosis and cognitive functioning (MMSE score) revealed a significant association between the presence of emboli and clinically relevant depressive symptoms: odds ratio=3.47 (95% CI 1.10–10.97), $P=0.034$. Of the cardiovascular risk factors, only a history of a myocardial infarction and/or angina was univariately associated with depressive symptoms at the 15% level (Pearson $\chi^2$, $P=0.147$). Including this variable in the model did not change the significance, giving a final odds ratio of 3.47 (95% CI 1.09–11.07), $P=0.035$. None of the included variables had a significant interaction with type of dementia, showing that diagnosis was not a major factor in explaining the association.

Semi-quantitative sensitivity analyses were performed by entering into our final model each non-significant cardiovascular risk factor and its interaction with type of dementia to check for differential effects in Alzheimer’s disease and vascular dementia. None of these variables nor their interaction with type of dementia approached significance or substantially confounded the relationship between clinically relevant depressive symptoms and spontaneous cerebral emboli. Furthermore, correction for cardiovascular risk factors that were previously associated with spontaneous cerebral emboli in healthy people (history of stroke or transient ischaemic attack, antiplatelet drugs and body mass index; see Purandare et al, 2006) did not change the results significantly (OR=4.19, 95% CI 1.18–14.90, $P=0.027$).

**DISCUSSION**
The presence of spontaneous cerebral emboli was significantly associated with the
occurrence of clinically relevant depressive symptoms in patients with dementia, independent of the level of cognitive functioning, age, gender and type of dementia. In addition, the relationship was unaffected by other cardiovascular risk factors, thereby confirming our hypothesis. Our findings are in line with previous research showing increased prothrombotic states and platelet activation in depression (Musselman et al, 1996). Cerebral emboli might be aetiologically linked to depressive symptoms in dementia by causing vascular damage to the frontostriatal pathways involved in depression or their modulating brain areas. Previous research has shown that patients with dementia and depression have significantly more severe white matter lesions (Barber et al., 1999) and cerebral microinfarcts (Ballard et al., 2000) than dementia patients without depression. The arbitrary distinction between white matter hyperintensities and microinfarction suggests at least partial overlap in aetiological factors, and spontaneous cerebral emboli might be one of these factors. Clark et al. (1998), however, did not find a significant relationship between a clinical diagnosis of depression and white matter hyperintensities in 31 patients with Alzheimer's disease, although clinician-rated depression scores were higher in patients with large anterior hyperintensities on magnetic resonance imaging.

The lack of association between cardiovascular risk factors and clinically relevant depressive symptoms in our study may be explained by the low prevalence of both in our sample. On the other hand, a substantial number of studies have found that vascular risk factors such as hypertension and diabetes are not an important cause of depression at a population level (Baldwin, 2005). Cervilla et al. (2004), for example, followed up 2584 people with moderate hypertension over 54 months and did not find an association between incident depressive symptoms and cardiovascular risk factors. Both general atherosclerotic disease and atrial fibrillation can generate arterial emboli, and both have been associated with depressive symptoms (Lyness et al., 1998; Tiemeier et al., 2004). In our sample, however, the two measures indicative of atherosclerosis (carotid artery disease and pulse pressure) were related neither to depressive symptoms nor to cerebral emboli (data not shown). Although we did not specifically investigate atrial fibrillation, it is unlikely to be a significant confounder because of the exclusion of patients taking anticoagulant medication.

The assessment of clinically relevant depressive symptoms was based on the Neuropsychiatric Inventory, which is a well-validated and highly reliable questionnaire. Forty-four per cent of our population scored positive on the NPI screening question for depression, which is in line with published findings of 23–55% of dementia patients scoring positive for depressive symptoms on the NPI (Lyketsos et al., 2000; Mirakhr et al., 2004). The significance of these symptoms, however, can be questioned (Lyketsos et al., 2000; Cummings, 2003; Holthoff et al., 2005), and an NPI cut-off score of 3/4 has been recommended to indicate clinically relevant depressive symptoms for clinical trials in Alzheimer's disease (Schneider et al., 2001). Based on the cut-off point of 3/4, the proportion of dementia patients with depressive symptoms decreases markedly and falls in the same range (11–25%) as studies in which depression of clinical significance is assessed according to DSM–IV (American Psychiatric Association, 1994) criteria (Burns et al., 1990; Cummings et al., 1995; Weiner et al., 2002). The fact that our prevalence rate of 11% is at the lower end suggests that patients with depression might have more often declined participation. This might also explain the relatively low proportion of women in our study. Our observation of the univariate association between cerebral emboli and depressive symptoms becomes too low for reliable multivariate analyses. Depressive symptoms in dementia fluctuate over time and are persistent in only a minority of patients (Ballard et al., 1996; Eustace et al., 2002). Starkstein et al. (1997) found that in patients with Alzheimer's disease, minor depressive symptoms were transient, whereas more severe symptoms suggestive of major depression persisted for over a year. Our criteria for clinically relevant depressive symptoms are more suggestive of major depression, and our hypothesis about the underlying mechanism – disruption of frontostriatal circuits owing to vascular damage by spontaneous cerebral emboli – may explain their persistence.

Some limitations of our study must be addressed. The cross-sectional assessment of depressive symptoms and emboli hinders causative interpretation. Second, the population studied was a convenience sample from specialist secondary care, limiting generalisation. For example, vascular dementia is a heterogeneous disorder, and we recruited relatively few patients with post-stroke dementia, who are thought to be at particular risk of developing depression. Finally, the assessment of depressive symptoms in our study was rather limited. We did not use a separate scale, such as (for example) the Cornell Scale for Depression in Dementia (Alexopoulos et al., 1988), to assess depressive symptoms in more depth, and made no attempt to diagnose clinical depression using established diagnostic criteria such as those of DSM–IV or ICD–10 (World Health Organization, 1992).

Although the vascular depression hypothesis is now established, the pathways between vascular risk and depression remain unknown. To our knowledge, depression in dementia has never been linked with spontaneous cerebral emboli. Our results provide preliminary support for the hypothesis that asymptomatic microembolic events might be involved in causation of clinically relevant depressive symptoms in dementia. Further research is required: first, to confirm our findings in a longitudinal design using standardised diagnostic criteria for depression; and second, to examine whether the relationship is unique to depressive symptoms in dementia or can be generalised to late-onset depression in general.

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