Risk factors and clinical features of craniocervical arterial dissection

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Craniocervical arterial dissection is one of the most common causes of ischaemic stroke in young people and is occasionally associated with neck manipulation. Identification of individuals at risk will guide risk management. Early recognition of dissection in progress will expedite medical intervention. Study aims were to identify risk factors and presenting features of craniocervical arterial dissection. Medical records of patients from the Hunter region of New South Wales, Australia aged ≤ 55 years with radiographically confirmed or suspected vertebral or internal carotid artery dissection, were retrospectively compared with matched controls with stroke from some other cause. Records were inspected for details of clinical features, presenting signs and symptoms and preceding events. Records of 47 dissection patients (27 males, mean age 37.6 years) and 43 controls (22 males, mean age 42.6 years) were inspected. Thirty (64%) dissection patients but only three (7%) controls reported an episode of mild mechanical trauma, including manual therapy, to the cervical spine within the preceding three weeks. Mild mechanical trauma to the head and neck was significantly associated with craniocervical arterial dissection (OR 23.53). Cardiovascular risk factors for stroke were less evident in the dissection group (< 1 factor per case) compared to the controls (> 3).

Introduction

Craniocervical arterial dissection (CAD) is one of the most common causes of ischaemic stroke in the young to middle aged population (Dittrich et al., 2007; Touze et al., 2003), accounting for 10-25% of all ischaemic stroke in this age group. It is considered to often occur spontaneously, without obvious cause, with an annual incidence of 2.5-3:10,000 (Dziewas et al., 2003; Schievinck, 2001).

There is limited evidence to suggest that young persons suffering a 'spontaneous' CAD may actually have a pre-existing but subclinical arteriopathy, vascular anomaly or genetic predisposition (Dittrich et al., 2007). Such intrinsic susceptibility may be caused by a number of different factors, such as subclinical connective tissue disorders (Brandt et al., 1998; Schievinck, 2001) or a more generalised arteriopathy (Volker et al., 2005). In patients with such an existing intrinsic susceptibility, exposure to an extrinsic trigger such as minor mechanical trauma to the neck or a recent infection or viral illness, may initiate dissection. Cervical spine manipulation has occasionally been associated with serious adverse events (Assendelft, Bouter, & Knipschild, 1996; Hurwitz, Aker, Adams, Meeker, & Shekelle, 1996), in particular dissection of the vertebral or internal carotid arteries (Paciaroni & Bogousslavsky, 2009). Recent infection has been proposed as a possible trigger for dissection, perhaps associated with the recognised seasonal variation of spontaneous CAD, with a peak in autumn and winter (Piacaroni et al., 2006; Schievinck, 2001); dissection potentially occurring due to the presence of pro-inflammatory mediators and an immunological host response causing temporary friability of the arterial wall (Guillon et al., 2003; Lindsberg & Grau, 2003).

Traditional risk factors for cardiovascular disease are not generally thought to be contributive in dissection as cases are generally under 55 years and therefore less likely to have developed associated conditions, such as atherosclerosis (Schievinck, 2001). Nonetheless, Kerry and colleagues have recommended that manual therapists should consider assessment of vascular risk factors (incorporating a system based approach) for all patients for whom manual treatment for the neck is proposed (Kerry, Taylor, Mitchell, & McCarthy, 2008).

If individuals with intrinsic susceptibility who may be at greater risk of dissection can be more readily identified, appropriate risk management for neck manipulation may

be applied. However, it is likely pre-manipulative protocols used by manual therapy practitioners, which often include provocative positional tests, do not identify all patients at risk and are not ideal for screening purposes (Kerry et al., 2008; Refshauge, 1994; Thomas, Rivett, & Bolton, 2009). Clinical screening is further complicated by the fact that signs and symptoms of CAD may include headache and neck pain, mimicking a musculoskeletal presentation. Indeed, some patients might actually seek treatment from a manual therapy practitioner for the painful symptoms of a dissection already in progress (Cassidy et al., 2008; Haneline & Lewkovich, 2005) and differential diagnosis may be difficult. If the early signs and symptoms of CAD can be more easily recognised, including the more subtle neurological findings, inappropriate interventions such as manipulation may be avoided and medical treatment expedited, potentially reducing the impact of the stroke.

Previous research has identified patients with CAD from hospital or stroke data banks, individual clinic records and medico-legal reports. Often these studies were uncontrolled and age limitations not always applied (Arnold et al., 2009; Haldeman, Kohlbeck, & McGregor, 2002; Haneline & Lewkovich, 2005). Findings are commonly inconsistent between studies and consensus has yet to be reached on definitive risk factors for dissection

The aim of the current study was to retrospectively investigate young patients, under 55 years, with radiologically confirmed or clinically suspected vertebral or internal carotid artery dissection presenting to hospital in the Hunter and Manning regions of New South Wales, Australia. Specifically, the aims were to identify risk factors for dissection from the patient history, examine and describe the presenting clinical features, and gain an understanding of the natural history and outcome for patients following CAD.

Methods

Cases of vertebral or internal carotid artery dissection were identified via the medical record coding system of the John Hunter Hospital between 1998 and 2009. This hospital is a large tertiary referral hospital of 550 beds servicing the Hunter and Manning regions with a population of approximately 617,000 (Australian Bureau of Statistics, 2009). The medical records database was searched using the international diagnostic coding system ICD-10 (World Health Organisation, 2007) for

patients with radiologically confirmed or suspected vertebral or internal carotid arterial dissection.

The database was searched in the following diagnostic categories:

- 1670 dissection of cerebral arteries non ruptured;
- 1630-1639 cerebral infarction unspecified;
- 1640 stroke not specified as haemorrhage or infection;
- 1660-1669 occlusion and stenosis of unspecified cerebral artery;
- 1650-1659 occlusion and stenosis of carotid artery.

Although some of these codes do not directly identify vertebral or internal carotid dissection, in case of possible miscoding it was expected that dissection cases would at least be coded under one of these categories. An additional search was also made of the hospital electronic discharge referral system using keywords of vertebral or internal carotid artery dissection. Throughout the course of the study regular communication with research and clinical staff of the neurology unit was made to identify any new dissection cases.

Inclusion criteria were all patients under 55 years with radiologically confirmed or suspected vertebral or internal carotid artery dissection. Control subjects were age and sex matched patients with a clinico-radiological diagnosis of stroke from some cause other than arterial dissection. Patients diagnosed with sub-arachnoid haemorrhage were excluded as this is a rare condition with a distinctively different presentation.

Once the medical record numbers of patients were identified, medical notes were retrieved and data extracted using a standardised data extraction proforma administered by the lead author. Information was sought in the medical notes of both dissection and control subjects about the presenting signs and symptoms of the stroke, the history of preceding events, in particular minor mechanical trauma and specifically manual treatment of the neck, pre-existing medical status including reports of any recent infection or febrile illness, and pre-existing cardiovascular risk factors. Details of any radiological and haematological investigations were also recorded.

Brain and vascular imaging was accessible through the John Hunter Hospital Picture Archiving Communication System (PACS) and was reviewed using a standardised proforma. The brain imaging was evaluated on-line by two experienced stroke neurologists (CL and MP) blinded to the case or control status. The imaging diagnosis of confirmed CAD was made by consensus.

The outcome of the stroke was recorded as a modified Rankin score (MRS) (van Swieten, Koudstaal, Visser, & Schouten, 1988). The MRS is widely used for assessing global outcomes following stroke. It has been demonstrated to have acceptable inter-rater reliability ($\kappa=0.71-0.95$) (van Swieten et al., 1988; Wilson et al., 2005; Wolfe, Taub, Woodrow, & Burney, 1991). The project was approved by the Hunter New England Area Human Ethics Committee.

Data analysis

Descriptive statistics were used to summarise the demographic data, outcomes and risk factors. Simple logistic regression was performed for the major risk factors identified. All factors with a p-value of 0.2 or less were included in a multiple logistic regression model; outcomes were expressed as odds ratios with 95% confidence intervals. Statistical analysis was performed using the STATA statistical /data analysis software (version 11, Statacorp, Texas, USA).

Results

The medical records of 47 dissection subjects and 43 age and sex matched controls were reviewed. Of the dissection subjects, 27 (57%) had sustained a dissection of the vertebral artery or basilar artery (VBAD) and 20 (43%) subjects had sustained a dissection of the internal carotid artery (ICAD). Subject demographics and characteristics are reported in Table 1. Of the subjects, 36 (77%) had radiographic confirmation of their dissection arrived at by consensus between the two reviewing neurologists (CL and MP). The neurologists were in agreement on all cases. For the remaining 11 subjects, diagnosis of dissection was based on suggestive history and clinical examination at the time of admission as well as radiological suspicion of dissection.

Risk factors

Thirty (64%) of the dissection subjects (17 VBAD, 13 ICAD) had a history of minor mechanical trauma to the neck (i.e. no evidence of fracture or dislocation) within the preceding three weeks, of which 11 (23%) subjects (8 VBAD, 3 ICAD) had a report of recent manual therapy to their neck (Tables 2a,b). An additional three (6%) subjects had a history of head trauma within the past several years. In contrast, only three (7%) control subjects had a history of recent mechanical trauma to the head or neck, and only one of these cases involved manual therapy to the cervical spine. This equates to an odds ratio (95% CIs) of 23.53 (6.31, 87.7) for mechanical neck trauma ($p<0.001$) and 12.8 (1.58, 104.28) for neck manual therapy ($p=0.009$), both of which remain significant in the adjusted model (adjusted for age and gender). The types of trauma are shown in Table 3.

Seventeen (36%) of the dissection subjects had radiological evidence of vessel abnormalities involving the posterior circulation, such as an ectatic or hypoplastic vertebral artery or one ending in the posterior inferior cerebellar artery. On the other hand, only seven (16%) control subjects had a report of vessel abnormalities within the cerebral circulation. The adjusted odds ratio of 3.0 (95% CI 0.99, 9.02) narrowly missed significance in the adjusted model.

Twelve (26%) of the dissection subjects had a history of recent infection or viral illness prior to their admission to hospital compared with just four (9%) of the control subjects, for an adjusted odds ratio of 3.77 (95% CI 1.07, 13.24). Dissections occurred most frequently during autumn and winter (30 subjects, 64%), whereas 53% (23 subjects) of strokes in the control group occurred during these seasons.

Blood investigations were inconsistently reported in the medical notes so no meaningful comparisons could be made between groups.

Cardiovascular risk factors

The occurrence of cardiovascular risk factors is reported in Tables 4a,b. Risk factors displaying statistical significance were hypertension, odds ratio (OR) 0.23 (95% confidence intervals (CI) 0.09, 0.58), smoking OR 0.22 (CI 0.13, 0.73) and elevated cholesterol OR 0.27 (CI 0.11, 0.66). Notably, these were more likely to occur in controls.

In general, the controls had considerably more cardiovascular risk factors than the dissection subjects; an average of 3.23 (SD 1.6) or more risk factors and other co-morbidities, in contrast to the dissection subjects who were generally without other co-morbidities until their dissection and had an average of 1.4 (SD 1.3) cardiovascular risk factors.

Subgroup analysis of risk factors was performed for the radiologically confirmed cases (i.e. excluding the 11 unconfirmed) and findings were similar except that recent infection was no longer significant ($p=0.29$) and vascular anomaly became significant ($p=0.13$) (Tables 2b and 4b).

Clinical presentation

The most commonly presenting feature in the dissection group was headache; reported by thirty eight (81%) subjects compared with 22 (51%) controls. The frequency and distribution of reported signs and symptoms are shown in Tables 5 and 6.

In subjects with VBAD, the most common signs and symptoms were headache, neck pain, dizziness and unsteadiness. Headache was present in 23 (85%) subjects, commonly in the occipital region (65% VBAD subjects), but notably was not present in all subjects and was not always severe. Dizziness was experienced by 14 (52%) subjects. Unsteadiness or ataxia was present in 18 (67%) subjects.

In subjects with ICAD, the most common signs and symptoms were headache, ptosis, facial palsy, and upper and lower limb weakness. Headache occurred in 15 (75%) subjects and was commonly reported in the retro-orbital (47%) or temporal (47%) regions. Ptosis and facial palsy each occurred in twelve (60%) subjects, upper limb weakness in 13 (65%) cases and lower limb weakness in ten (50%).

In the control group, which comprised largely anterior circulation stroke, headache was a presenting feature in only 22 (51%) of subjects and was not localised to any particular region. Dysphasia (30 subjects, 70%), upper (32 subjects, 74%), and lower limb weakness (26 subjects, 60%), upper limb paraesthesia (20 subjects, 47%) and facial palsy (20 subjects, 47%) were much more commonly reported in controls.

Outcome

The majority (72%) of patients in both the dissection and control groups had a favourable outcome i.e. MRS ≤ 2 (Table 7). A MRS of 2 means a patient is able to walk and manage their own affairs (van Swieten et al., 1988).

Discussion

The present investigation is the first retrospective study of CAD patients from a manual therapy perspective. It is one of few case controlled studies of dissections and importantly used a representative sample of young strokes rather than those potentially more severe cases who might undertake medico-legal action. The overarching aim was to identify key findings which may be of use to manual therapy practitioners in the management of patients presenting with neck pain or headache, and specifically to help therapists identify those patients in whom manual therapy may be inappropriate.

Risk factors

The main finding of our study in the identification of risk factors was that there was a statistically significant association of recent minor mechanical trauma, including manual therapy to the neck, and CAD, in comparison to a control group. This finding is consistent with that of other authors investigating CAD, though not all previous studies used a control group (Dittrich et al., 2007; Dziewas et al., 2003; Touze et al., 2003). It is therefore important for manual therapy practitioners to be aware of the possibility of arterial dissection in a patient presenting with headache or neck pain and reporting a recent history of even minor head or neck trauma. In such cases, manual therapy practitioners should be particularly alert to the presence of other more subtle neurological signs and symptoms such as balance impairments, ptosis or visual disturbances. Moreover, the results of the study serve to caution practitioners to use minimal force when treating the cervical spine and to be alert to the potential dangers of a patient suddenly developing neck pain or headache following manual treatment to the neck (Smith et al., 2003).

All presenting young stroke patients are routinely questioned about previous manual therapy to the neck in our neurology unit, so it was possible to compare this factor between the groups. Therefore the potential limitation of this question not having

being asked of the control patients was less likely in our study, although it is acknowledged that a negative response may not have always been recorded. However, when patients had reported prior manual treatment, no detail of the type or procedure was recorded. It was thus not possible to determine the relative risk of one type of manual therapy (e.g. manipulation), let alone specific technique, over another. Although therapists may feel safer in using gentler manual techniques, it should be borne in mind that the condition they are treating could in fact be a dissection mimicking a musculoskeletal presentation. Therapists must therefore be able to recognise a possible dissecting artery and expedite onward medical referral, rather than risk being implicated in the cause or potentially progressing the pathology (Cassidy et al., 2008).

Although recent infections occurred more frequently in the dissection group and dissections were more common in autumn and winter compared to the control group, this factor was of borderline statistical significance in this study ($p=0.04$). This may have been due to low numbers of subjects or reporting bias of minor conditions. Similarly information on blood results, which may have helped identify any inflammatory factors, was limited. Although information about recent infections or viral illness was reported as part of the normal history taken on admission to hospital, data were not available on their temporal relationship to the subject's stroke. Despite this, it may be prudent for clinicians to question patients about recent infection or viral illness and be cautious of more vigorous techniques in such cases.

Recently Kerry et al (2008) have recommended that manual therapists should consider vascular risk assessment (incorporating a system based approach) of patients prior to treatment of the neck. However cardiovascular risk factors commonly associated with stroke were not strongly represented in this dissection group in comparison to the non-dissection controls. Data on cardiovascular risk factors in a similar age general population in Australia is not available except for smoking (20%). Smoking is reported as being slightly higher in the dissection group (33%) but this is about half the rate of the non-dissection group (65%)(Australian Bureau of Statistics, 2009; Australian Institute of Health and Welfare, 2005). Indeed, this study there was a mean of 1.4 cardiovascular risk factors per dissection subject compared with 3.23 in the non-dissection group. This suggests that in younger patients, routine assessment of such factors in the patient examination (e.g. taking

of blood pressure) may not be particularly useful for manual therapists in determining the risk of adverse neurovascular events following manual therapy to the cervical spine.

Signs and symptoms

Considering some current clinical recommendations and pre-manipulative guidelines for practitioners employing manual therapy for neck disorders (George, Silverstein, Wallace, & Marshall, 1981; Kerry et al., 2007; Rivett, Shirley, Magarey, & Refshauge, 2006), it is important to note that headache was not always present and not always severe in either VBAD or ICAD subjects, although it was more common in VBAD (85%) and ICAD (75%) subjects than controls (51%). Similarly, neck pain and dizziness were more likely to occur in VBAD than ICAD subjects or controls. It was particularly surprising to find that dizziness was present in only 52% of the VBAD cases, yet this symptom has often been stressed as the primary clinical indicator of vertebrobasilar flow insufficiency (Grant, 1988; Maitland, 2005; Petty, 2006). The presence or absence of nystagmus was rarely recorded, although other visual disturbances were reported. Ataxia or balance problems were also a fairly common finding in the VBAD group (67%), so manual therapists should be alert to this finding in an assessment of a patient with neck pain or headache and perhaps consider formal testing of balance more routinely. Similarly findings for the ICAD cases suggest it may be appropriate to perform a focused cranial nerve examination (e.g. for facial palsy or ptosis) if specific symptoms are reported in the history or signs are evident on casual observation.

One of the main limitations of retrospective studies is that medical records are not always detailed and it is acknowledged that negative responses to questions in the history may not always be recorded. Details of blood results and radiological imaging were sometimes limited. Radiological imaging such as magnetic resonance angiography (MRA) and computerised tomographic angiography (CTA) are not always sensitive enough to detect the more subtle signs of dissection, in particular vertebral artery dissection (Levy et al., 1994; Vertinsky et al., 2008). Furthermore, if imaging is not performed within a few days of the onset of symptoms it may not provide evidence of a dissection, despite an initial clinical diagnosis of dissection. Radiographic findings may change in a matter of days or even hours (Schievinck, 2001). Indeed, in our study radiological confirmation of dissection was not possible

in all subjects; 11 subjects did not have clear radiological evidence at the time the imaging was performed and in some cases this was a few weeks or even months after the onset of their symptoms. A further limitation of the current study is that the sample size is modest, reflecting the relative rarity of CAD and despite electronic records at a large tertiary teaching hospital being searched over a 12 year period. Finally, although the study was limited to subjects under 55 years, as this is the subgroup in whom CAD complications are most commonly reported, it is possible that other serious neurovascular complications may occur in older people.

Future studies should ideally be undertaken prospectively to ensure all relevant clinical information can be collected for both dissection and control cases, including timely imaging. Ideally future studies should also be multi-centre to ensure a greater number of subjects are captured so that more meaningful analysis of associations can be made between groups for different factors.

Considering the results, there is clearly a significant association between recent minor mechanical trauma, including manual therapy, to the cervical spine and CAD. Manual therapists should therefore be alert to such a history in patients presenting with head and neck pain and be prepared to perform a focused neurological examination, where indicated, for subtle neurological signs and symptoms. Practitioners should also be aware that these patients may present complaining of severe headache or neck pain, but not always, and that dizziness which has traditionally been associated with VBAD is only present in about half of the cases. It is anticipated that the results of this study will enable clinicians to better recognise a dissection in progress and the factors potentially associated with an increased risk of an adverse neurovascular event from manual therapy to the neck.

Conclusion

Recent minor mechanical trauma, including manual therapy to the cervical spine, is significantly associated with CAD. General cardiovascular risk factors do not appear to be strongly represented in CAD patients, suggesting they may not be useful indicators of the risk of adverse neurovascular complication associated with manual treatment of the neck. However, there may be other types of serious neurovascular complications which could indeed exhibit such factors. The utility of assessing for cardiovascular risk factors should therefore not be dismissed on these data alone.

Manual therapists need to be aware of the more common symptoms of a dissection in progress, some of which may mimic a mechanical neck disorder, and be prepared to test for subtle neurological signs, such as imbalance or cranial nerve impairment.

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Captions

Table 1
Subject characteristics

Table 2a

Risk factors identified in dissection and control subjects. *Multiple regression analysis with odds ratios adjusted for age and gender
VBA = vertebrobasilar artery ICA = internal carotid artery
§ anomalies involving the posterior circulation such as ectatic or hypoplastic VA or VA ending in posterior inferior cerebellar artery (PICA).

Table 2b

Risk factors identified in dissection and control subjects: subgroup analysis of radiologically confirmed cases. *Multiple regression analysis with odds ratios adjusted for age and gender
VBA = vertebrobasilar artery ICA = internal carotid artery
§ anomalies involving the posterior circulation such as ectatic or hypoplastic VA or VA ending in posterior inferior cerebellar artery (PICA).

Table 3

Breakdown of types of minor mechanical trauma described in patient history. Note that trauma may have been categorised under more than one type.

Table 4a

Cardiovascular risk factors identified in dissection and control subjects. *Multiple regression analysis with odds ratios adjusted for age and gender

Table 4b

Cardiovascular risk factors identified in dissection and control subjects: subgroup analysis of confirmed cases. *Multiple regression analysis with odds ratios adjusted for age and gender

Table 5

Reported symptoms in the dissection and control subjects (UL=upper limb, LL=lower limb) VBA = vertebrobasilar artery ICA = internal carotid artery

Table 6

Reported clinical signs in the dissection and control subjects (UL=upper limb, LL=lower limb) VBA = vertebrobasilar artery ICA = internal carotid artery

Table 7

Stroke outcome in terms of disability (expressed as a Modified Rankin Score [MRS]) for dissection and control subjects. MRS $\leq$ 2 means patient is able to walk and manage their own affairs

Table 1

Subject characteristics	Dissection subjects N=47	Control subjects N=43	P value
Vertebrobasilar artery territory	27 (57%)	5 (12%)	<0.0001
Radiological confirmation	20 (74%)	5 (100%)	<0.0001
Clinical diagnosis but no imaging confirmation	7 (26%)	0	-
Internal carotid artery territory	20 (43%)	38 (88%)	<0.0001
Radiological confirmation	16 (80%)	38 (100%)	<0.0001
Clinical diagnosis but no imaging confirmation	4 (20%)	0	-
Age yrs $\pm$ sd	37.6 $\pm$ 10	43.6 $\pm$ 7.3	0.42
Males	27	22	0.7

Table 2a

Risk factor	Dissection subjects N=47	Control subjects N=43	Odds ratio (95%CI)	Adjusted odds ratio* (95%CI)	P value
Recent head or neck trauma	30 (64%) (17 VBA, 13 ICA)	3 (7%)	23.53 (6.31, 87.70)	23.51 (5.71, 96.89)	<0.000
Neck manual therapy	11 (23%) (8 VBA, 3 ICA)	1 (2%)	12.8 (1.58, 104.28)	12.67 (1.43,112.0)	0.009
Recent infection	12 (26%) (6 VBA, 6 ICA)	4 (9%)	3.34 (0.99,11.32)	3.77 (1.07,13.24)	0.040
§ Craniocervical vascular anomaly	17 (36%) (17 VBA)	7 (16%)	2.62 (0.90, 7.60)	3.0 (0.99, 9.02)	0.068

Table 2b

Risk factor	Confirmed dissection subjects N=36	Control subjects N=43	Odds ratio (95%CI)	Adjusted odds ratio* (95%CI)	P value
Recent head or neck trauma	23 (64%) (13 VBA, 10 ICA)	3 (7%)	26.67 (6.83, 104.17)	25.29 (6.04, 105.82)	<0.000
Neck manual therapy	8 (22%) (7 VBA, 1 ICA)	1 (2%)	12.0 (1.42, 101.30)	12.67 (1.43,112.0)	0.022
Recent infection	8 (22%) (4 VBA, 4 ICA)	4 (9%)	1.94 (0.62,6.08)	1.90 (0.58,6.22)	0.287
§ Craniocervical vascular anomaly	14 (39%) (9 VBA, 5 ICA)	7 (16%)	3.27 (1.14, 9.36)	4.46 (1.37, 14.60)	0.013

Table 3

Minor mechanical trauma	Dissection subjects n=30	Control subjects n=3
Manual therapy	11 (6 chiro, 2 massage, 1 osteo, 2 physio)	1 (osteo)
Sport with direct trauma to head/neck	9 (1 martial arts, 4 fall from horse/ bike/ wakeboard, 1 rugby, 1 netball, 1 gymnastics, 1 head clash)	0
Heavy lifting	3 (1 boxes, 2 gym work)	0
Motor vehicle accident	2	1
Direct trauma to neck	2 (1 twisting, 1 attempted hanging)	0
Indirect trauma to neck	3 (1 show ride, 1 horse riding, wisdom teeth extraction)	1 (playing squash)

Table 4a

Risk factor	Dissection subjects N=47	Control subjects N=43	Odds ratio (95%CI)	Adjusted odds ratio* (95%CI)	P value
Hypertension	9 (19%)	23 (53%)	0.23 (0.09, 0.58)	0.29 (0.11, 0.79)	0.001
Current or past smoker	14 (30%)	28 (65%)	0.31 (0.13, 0.73)	0.31 (0.13, 0.78)	0.001
High cholesterol	11 (23%)	23 (53%)	0.27 (0.11, 0.66)	0.33 (0.12, 0.85)	0.001
Family history of stroke	4 (9%)	6 (14%)	0.40 (0.13, 1.29)	0.55 (0.16, 1.88)	0.126
Oral contraception	5 (11%)	4 (9%)	1.46 (0.38, 5.58)	1.32 (0.31, 5.69)	0.578
Migraine	11 (23%)	8 (19%)	1.62 (0.56, 4.64)	1.54 (0.51, 4.67)	0.373

Table 4b

Risk factor	Confirmed dissection subjects N=36	Control subjects N=43	Odds ratio (95%CI)	Adjusted odds ratio* (95%CI)	P value
Hypertension	7 (19%)	23 (53%)	0.23 (0.83, 0.64)	0.28 (0.09, 0.85)	0.005
Current or past smoker	12 (33%)	28 (65%)	0.33 (0.13, 0.83)	0.33 (0.13, 0.89)	0.018
High cholesterol	8 (22%)	23 (53%)	0.25 (0.92, 0.67)	0.28 (0.10, 0.82)	0.006
Family history of stroke	4 (11%)	6 (14%)	1.86 (0.69, 4.98)	2.18 (0.76, 6.26)	0.213
Oral contraception	5 (14%)	4 (9%)	1.53 (0.38, 6.36)	1.69 (0.38, 7.63)	0.525
Migraine	10 (28%)	8 (19%)	1.98 (0.66, 5.88)	1.99 (0.64, 6.27)	0.220

Table 5

Symptoms	VBAD N=27	ICAD N=20	Total Dissection subjects N=47	Control subjects N=43
Headache	23 (85%)	15 (75%)	38 (81%)	22 (51%)
Neck pain	18 (67%)	9 (45%)	27 (57%)	6 (14%)
Dizziness	14 (52%)	1 (0.5%)	15 (32%)	3 (7%)
Visual disturbance	9 (33%)	7 (35%)	16 (34%)	12 (28%)
Paraesthesia (face)	8 (30%)	6 (30%)	14 (30%)	8 (19%)
Paraesthesia (UL)	9 (33%)	7 (35%)	16 (34%)	20 (47%)
Paraesthesia (LL)	4 (15%)	5 (25%)	9 (19%)	14 (33%)

Table 6

Signs	VBAD N=27	ICAD N=20	Total dissection subjects N=47	Control subjects N=43
Unsteadiness/ataxia	18 (67%)	8 (40%)	26 (55%)	15 (35%)
Weakness (UL)	9 (33%)	13 (65%)	22 (47%)	32 (74%)
Weakness (LL)	11 (41%)	10 (50%)	21 (45%)	26 (60%)
Dysphasia/dysarthria/ aphasia	12 (44%)	9 (45%)	21 (45%)	30 (70%)
Facial palsy	6 (22%)	12 (60%)	18 (38%)	20 (47%)
Ptosis	5 (19%)	12 (60%)	17 (36%)	2 (5%)
Nausea/vomiting	7 (26%)	6 (30%)	13 (28%)	6 (14%)
Dysphagia	7 (26%)	1 (0.5%)	8 (17%)	2 (5%)
Drowsiness	1 (4%)	4 (20%)	5 (11%)	1 (2%)
Confusion	2 (7%)	3 (15%)	5 (11%)	6 (14%)
Loss of consciousness	4 (15%)	4 (20%)	8 (17%)	2 (5%)

Table 7

MRS	Dissection subjects N=47	Control subjects N=43
Favourable ≤ 2	34	31
Unfavourable > 2	10	8
Ungraded	3	4