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## Vertebral artery dissections after chiropractic neck manipulation in Germany over three years

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■ **Abstract** Vertebral artery dissection (VAD) has been observed in association with chirotherapy of the neck. However, most publications describe only single case reports or a small number of cases. We analyzed data from neurological departments at university hospitals in Germany over a three year period of time of subjects with vertebral artery dissections associated with chiropractic neck manipulation. We conducted a countrywide survey at neurological departments of all medical schools to identify patients with VAD after chirotherapy followed by a standardized questionnaire for each patient. 36 patients (mean age 40 + 11 years) with VAD were identified in 13 neurological departments. Clinical symptoms consistent with VAD started in 55 % of patients within 12 hours after neck manipulation. Diagnosis of VAD was established

in most cases using digital subtraction angiography (DSA), magnetic resonance angiography (MRA) or duplex sonography. 90 % of patients admitted to hospital showed focal neurological deficits and among these 11 % had a reduced level of consciousness. 50 % of subjects were discharged after 20 ± 14 hospital days with focal neurological deficits, 1 patient died and 1 was in a persistent vegetative state. Risk factors associated with artery dissections (e. g. fibromuscular dysplasia) were present in only 25 % of subjects.

In summary, we describe the clinical pattern of 36 patients with vertebral artery dissections and prior chiropractic neck manipulation.

■ **Key words** chiropractic · neck manipulation · artery dissection · disability

### Introduction

Spinal manipulation has become increasingly popular since the introduction of this technique in the 18<sup>th</sup> century. In the last decade about 10 million patients accounted for 125 million chiropractor visits annually in the western world for a variety of reasons. Among these headaches and musculoskeletal disorders such as neck and back pain are most frequent. The risk for severe vascular or neurological complications due to chiropractic is not clear and has been estimated between 1/5.85 mil-

lion and 1/100,000 manipulations and therefore considered relatively low [1, 30]. However, some authors consider these numbers underestimated due to underreporting. In addition, most recent prospective surveys among chiropractors investigating the side effects of spinal chiropractic indicate mild and moderate transient adverse events (e. g. local discomfort, headache) in up to 50 % of all cases [28, 29].

Several fatal neurological complications such as vertebral artery dissection and combined vertebral and carotid artery dissection have been documented after cervical manipulation in case reports and question the

benefit and risk of this procedure [14, 19, 20, 31]. Moreover, it has been estimated that vertebral artery dissections due to cervical chiropractic cause lead to death in 18%, and in 52% to permanent neurological deficits [1, 8]. The frequency of such adverse events is thought to increase. A recently published study by Smith et al. demonstrated an independent association of vertebral artery dissections with spinal manipulative treatment within 30 days [32]. In line, Rothwell and colleagues revealed a correlation between recent chiropractic visits with a cervical diagnosis and the risk for vertebral artery dissections in patients younger than 45 years [22]. In the same age group an association between the number of visits (> 3) and the risk for vertebral artery dissections was demonstrated. Although a link between chiropractic and VAD has been clearly established a population at particular risk has not been identified.

The incidence of cervical artery dissections is not clear. While Schievink et al. estimate that per 100,000 strokes/year 2.6 are caused by spontaneous dissections of the cervical arteries other studies implicate that in the younger population (< 45 years) up to 20% of all strokes are associated with dissections of the vertebral or carotid arteries [7, 23, 24]. The annual incidence of spontaneous vertebral artery dissections is estimated between 1 and 1.5/100,000 [27]. In Ontario, about 0.43% of all hospitalized strokes between 1993–1998 were due to vertebral artery dissections [22]. Cranial artery dissections can be caused by a variety of reasons such as minor head or neck trauma, after forced reclination or spontaneously. In particular the vertebral artery is susceptible to injury due to its exposed position as it enters the skull base. Here, the vertebral artery changes directions from a vertical path to a horizontal path and is susceptible to rotation and tilting of the neck.

Despite the valuable recent advances in epidemiology the characteristics of cerebral ischemic strokes due to VAD after cervical chiropractic manipulation have not been studied systematically. We describe the clinical characteristics of 36 patients with cerebral ischemia and vertebral artery dissections due to cervical chiropractic manipulation within Germany in a 3 year period of time.

## Methods

All university affiliated neurological departments within Germany were contacted by mail and asked whether patients had been admitted to hospital in the last three years with the diagnosis of vertebral artery dissections (VAD) related to chiropractic therapy of the neck. In addition, we asked if these institutions were willing to participate in a retrospective survey with the aim to collect data from the above mentioned patients from multiple centers. A questionnaire was sent to all participating departments which had to be completed by a physician on a case by case base. General questions to be answered assessed age, sex, general and cardiovascular risk factors and disorders which are frequently seen with artery dissections (e. g. fibromuscular

dysplasia, migraine, autoimmunopathies). Head or neck traumas were evaluated as were all accompanying disorders. We did not specifically explore infections. Another series of questions evaluated circumstances of the chiropractic maneuvers. We asked for reasons why the neck manipulation was performed and also what the qualification of the conducting person was. Finally, the time course for the development of clinical symptoms after neck manipulation agreeable with the diagnosis of vertebral artery dissection was assessed and the nature of these clinical symptoms.

Clinical criteria for VAD after chirotherapy were “de novo” headache and/or new onset of clinical symptoms within 5 days after neck manipulation that could be attributed to the vertebral artery territory. We asked specifically for the following symptoms: vertigo, ocular nerve paralysis, facial sensory deficit, pupillomotor deficit, VII, VIII, IX, X, XI, XII nerve paralysis, hemiparesis, impaired level of consciousness, autonomic/sympathetic deficits, decussate brainstem signs and cerebellar deficits.

## Results

21/32 academic neurology centers within Germany replied to our start up letter and agreed to contribute data to this retrospective clinical survey. Eleven centers reportedly did not admit any patient with VAD related to neck chirotherapy during the observation period. All other academic centers received the questionnaire. In total, 13 centers reported a total of 40 cases with vertebral artery dissections after cervical chirotherapy. 4 cases from one medical school had to be excluded because the dissections occurred prior to the observation period.

### Patient characteristics

Data from 36 queries were analyzed. Mean age of the subjects (24 F/12 M) was  $40 \pm 11$  years.

#### ■ Time course and symptoms after chiropractic neck manipulation

Clinical symptoms consistent with the occurrence of vertebral artery dissection started in 72% within 2 days after the cervical manipulation. Five subjects showed clinical symptoms during and 4 subjects within one hour after the chiropractic maneuver. In all but one patient (35/36) these symptoms were unknown before and clearly distinguishable from complaints that led to chiropractic. In 20 subjects the most prominent clinical signs and symptoms could be attributed undoubtedly to brain areas that are supplied by the vertebral arteries (Table 1). A new headache was the main reason for the consultation in only 8 patients. The headache was referred to the occiput in 6 patients and in 2 patients to the neck. Dizziness was one, but not the only complaint of 20 subjects. Some patients (n = 5) also reported progression of previous symptoms. However, all of these had ad-

**Table 1** Patient characteristics

Age (years)	40.3 ± 11	
Sex	24 female : 12 male	
Hospital days	20 ± 13	
Cardiovascular risk factors		n = 22 (61%)
Disorders associated with VAD (e. g. migraine, FMD)	Yes No	n = 9 (25%) n = 27 (75%)
Latency (manipulation/ onset of complaint)	Within session < 60 mins 1–6 hrs 6–12 hrs 12–48 hrs > 48 hrs	n = 5 (14%) n = 4 (12%) n = 5 (14%) n = 7 (20%) n = 5 (14%) n = 9 (24%)
Chief complaint prior to chiropractic manipulation	Neck muscle tension Tension type headache Migraine Vertigo Lower back pain	n = 27 (75%) n = 7 (20%) n = 1 (3%) n = 1 (3%) n = 2 (6%)
Debilitating maneuver was conducted by	Orthopedic surgeon Physiotherapist Chiropractor GP Neurologist Homeopath Unknown	n = 18 (50%) n = 5 (14%) n = 4 (11%) n = 2 (6%) n = 1 (3%) n = 1 (3%) n = 3 (9%)
Chief complaint after chiropractic neck manipulation	Clinical symptoms attributed to the vertebrobasilar territory Any focal neurological deficit Newly developed neck/head pain Progression of symptom Impaired level of consciousness	n = 20 (56%) n = 32 (89%) n = 8 (22%) n = 5 (14%) n = 4 (11%)

ditional new symptoms that were attributed to the VA territory.

### ■ Clinical characteristics

Neurological examination on admission showed a NIHSS score of 4.3 (median 3, range 0–32) and 3.43 (median 1.5, range 0–13) on discharge. Despite the diagnosis of VAD by imaging techniques 6 patients did not show any focal deficits. In these occipital pain (n = 5) or unspecific complaints (n = 1) led to admission. Neurological deficits included impaired level of consciousness (n = 4), caudal cranial nerve deficits (n = 10), deficits of facial sensitivity (n = 10) and autonomic deficits (e. g. miosis n = 11; Table 2). Ten patients were discharged without any clinical neurological deficits, 1 patient died and 8 subjects were discharged with severe impairment (Table 3). On discharge caudal cranial nerve impairment (n = 3), autonomous dysfunction (n = 6) and loss of trigeminal sensory perception in the face (n = 7) were found. Compared to the physical neurological examination on admission 9 patients (25%) did not have any or very minor improvement in their clinical symptoms.

Eight patients had to be admitted to an intensive care

**Table 2** Clinical symptoms on admission and discharge

	On admission	On discharge
NIHSS score (median)	3	1.5
Facial sensory deficit	10 (28%)	7 (20%)
Hypacusis	1 (3%)	2 (6%)
Caudal cranial nerve deficit	10 (28%)	3 (9%)
Miosis/Ptosis/Horner syndrome	11 (31%)	6 (17%)
Impaired level of consciousness	4 (11%)	1 dead 1 vegetative state
Total no. of patients with a neurological deficit	30	18

unit because of a reduced level of consciousness (n = 2), extended neurological deficit for observation (n = 5) or a reduced swallowing reflex (n = 1). Both patients with reduced vigilance levels were mechanically ventilated because of respiratory impairment and stayed for 28 and 16 days. All other patients could be discharged from ICU after 2 days. In hospital treatment for VAD after chiropractic therapy was 20 ± 14 days and 6 patients stayed longer than 1 month in hospital.

**Table 3** Clinical scores of patients on hospital discharge assessed by the Modified Rankin Scale

	On discharge
0 No symptoms at all	10 (27%)
1 No significant disability despite symptoms; able to carry out all usual duties and activities	11 (30%)
2 Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance	6 (16%)
3 Moderate disability; requiring some help but able to walk without assistance	3 (9%)
4 Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance	4 (11%)
5 Severe disability; bedridden, incontinent and requiring constant nursing care and attention	1 (3%)
Dead	1 (3%)

### ■ Stroke imaging

In 27 patients brain imaging techniques demonstrated cerebral ischemia within the territory supplied by the VA arteries in line with the clinical findings. Strokes were confirmed by lesions in cerebral MRI ( $n = 20$ ) or cCT ( $n = 7$ ). Nine subjects did not have any signs of stroke in MRI or CT imaging. We did not evaluate stroke location (e. g. brainstem vs. cerebellum) in further detail.

### ■ Assessment and confirmation of VAD dissection

The diagnosis of vertebral artery dissection was confirmed in 19 cases by digital subtraction angiography (DSA). In 9 patients MR-angiography and in one subject CT-angiography were used as a primary tool to establish the diagnosis of VAD. In 5 subjects Doppler ( $n = 1$ ) or Duplex sonography ( $n = 4$ ) were used as the primary diagnostic tools. After establishing the diagnosis of VAD additional investigations were conducted in all patients to further prove the diagnosis. Fibromuscular dysplasia was diagnosed by DSA in 2 patients.

### ■ Drug treatment

Thirty-five patients (97%) received intravenous anticoagulation with heparin for  $12 \pm 7$  days without any side effects followed by secondary prophylaxis with cumarin derivatives ( $n = 31$ ; INR: 2–3) or acetylsalicylic acid ( $n = 1$  for each dose of 100 mg, 300 mg and 1000 mg/day) in 3 subjects. Anticoagulation was performed in the majority of subjects for 6 ( $n = 20$ ) or 12 months ( $n = 9$ ). In 3 patients anticoagulation was given further on.

### ■ Cervical manipulations

No neck or head trauma prior to chirotherapy was reported. The chief complaints that led to cervical manipulation included: tension/pain in neck muscles ( $n = 24$ ), tension type headache ( $n = 7$ ), migraine ( $n = 1$ ), vertigo ( $n = 1$ ), lower back pain ( $n = 2$ ). Scintillations ( $n = 1$ ), nausea ( $n = 1$ ) and paraesthesia ( $n = 1$ ) were other reasons for the intervention.

All cervical manipulations were performed in different private practices. Orthopedic surgeons conducted the neck manipulation in 18 subjects. Four procedures were conducted by a chiropractor and 5 by a physiotherapist while maneuvers performed by neurologists ( $n = 1$ ), homeopaths ( $n = 1$ ) and general practitioners ( $n = 2$ ) accounted for 4 incidents. Twelve subjects had cervical chiropractic manipulations repeatedly prior to the incident, which led in some patients (33%) to a relief of complaint on occasion.

### ■ Risk factors and comorbidity

General cardiovascular risk factors were existent pre-chirotherapy in 22 subjects (61%) with 10 subjects having more than one risk factor. Oral contraception was reported in 11 females and this was accompanied in 4 women by a second risk factor (nicotine  $n = 3$ ; hypertension  $n = 1$ ).

Migraine was previously diagnosed in 6 subjects and an unclassified autoimmunopathy in 1 female subject. This female also used oral contraception. In 2 patients (1F/1M) fibromuscular dysplasia was diagnosed during hospital stay after the procedure. One of the latter had undergone neck chirotherapy without complications repeatedly prior to the dissection.

## Discussion

We have summarized data from 36 patients with vertebral artery dissections following chiropractic manipulation of the neck. Most importantly vertebral artery dissections resulted in 2 casualties, and 24 more subjects were discharged from hospital with, in part, severe neurological deficits.

We provide evidence that in the cases presented here vertebral artery dissections are caused by chiropractic neck manipulation. A substantial number of subjects had an immediate begin of neurological deficits or complaints in accordance with the assumption of an immediate rupture of the vessel wall resulting in cerebral perfusion deficit and stroke [13, 15]. Alternatively, the dissection could cause a slowly progressing obliteration of the vertebral artery or thrombus formation followed by infarction within the vertebrobasilar artery territory.

This mechanism could account for a delayed onset of clinical symptoms and is in accordance with previous reports from the literature [4]. Based on the patients history we do not have any evidence that in our subjects vertebral artery dissections already existed prior to the “eventful” chiropractic manipulation. The onset of a new pain with a different character than the pain or complaint that led to chiropractic indicate a change of the source of pain and its underlying pathophysiology. In addition, the acute or subacute development of focal neurological deficits imply new onset underlying pathology. From our point of view these are arguments against a simple coincidence of vertebral artery dissection and neck manipulation in the overwhelming majority of cases.

This study does not point to a common predisposition in the population described in line with the report by Hufnagel et al. [15]. Others also failed to identify a population at special risk for stroke as a complication of chiropractic cervical treatment [16]. None of the patients in this report suffered from Ehlers-Danlos syndrome, Marfan syndrome, polycystic kidney disease, hyperhomocysteinuria or osteogenesis imperfecta, which are well characterized risk factors for spontaneous artery dissections [5, 21–33]. Only three subjects were diagnosed with connective tissue diseases such as fibromuscular dysplasia [10]. Fibromuscular dysplasia is not a risk factor for dissections but can be found in 15% of patients with spontaneous dissections of the carotid or vertebral arteries. It is also linked to several other systemic disorders and therefore lacks specificity [25].

Because the survey was conducted among neurologists involved in the treatment of VAD following cervical spine manipulative treatment we do not know which manipulative technique has been used in each of our subjects. It has been suggested that omitting rotation and extension of the neck during the cervical maneuver would reduce the risk of complications [1]. In contrast, a recent study by Haldeman et al. clearly demonstrated that VAD and strokes occur independently of the manipulative technique [12]. In an analysis of 64 cases they found that either chiropractic technique such as rotation, extension, lateral flexion, on-force and neutral position manipulation can cause vertebral artery dissection. Therefore, our analysis may only be affected to a minor extend by not assessing this information in detail. Future research with case to case comparisons will allow to identify the risk of specific manipulation techniques.

Most incidents occurred following manipulations conducted by orthopedic surgeons (50%). This finding clearly stands against the argument that the complication rate of chiropractic manipulations is dependent on the degree of education and the specific knowledge of the person performing the cervical manipulation [3]. On the other hand the finding that most complications occurred after chiropractic by orthopedic surgeons may

also reflect that most manipulations are conducted by this group of medical specialists in Germany. Complications also occurred when the manipulation was carried out by neurologists, chiropractors or GPs.

A substantial number of patients (33%) had multiple chiropractic cervical manipulations with and without symptom relief and without complications before the debilitating maneuver. The observation of multiple manipulations without success or only short term relief is in line with the ongoing debate whether chiropractic manipulation is a beneficial treatment for the disorders it is used for (e.g. neck or head pain) [2, 16]. Our data also show limited success of the treatment in this population. Moreover, artery dissections can occur following multiple cervical visits or after the first visit, which is in accordance with reports from the literature. In addition, multiple visits without adverse events do not exclude the occurrence of complications [13, 24].

There is consensus on the treatment of vertebral artery dissections after chiropractic among the neurologists participating in this study. Almost all subjects received heparin initially for about 2 weeks which was followed by anticoagulation with cumarin derivates for 6 to 12 months with an INR target of 2–3. Although there are no randomized prospective trials on the treatment regimen for dissections heparin has been advocated for the last 30 years [17, 26]. Indirect evidence exists for the appropriateness of this treatment. Most strokes are due to thrombotic events and intracranial microemboli have been observed using ultrasound. Although not used in any of the patients antiplatelet drugs may serve as an alternative treatment in some cases.

About 52% of patients with vertebral artery dissections after chiropractic neck manipulation remain physically impaired due to neurological deficits and 18% of patients die pointing to an overall poor prognosis [1]. In contrast, patients with spontaneous vertebral or carotid dissections have a substantially better prognosis with a death rate less than 5% and a good functional recovery in 70–80% although quality of life appears to be more severely affected [6, 9, 18, 25]. In our study 16% of patients were severely affected on discharge. Dziewas and colleagues reported no difference in the outcome in a series of patients with vertebral and carotid artery dissections due to different causes. In their study 15% of subjects with CAD and 9% with VAD died or were severely handicapped [35]. Among others age, gender and FMD were not related to the outcome. In contrast, stroke and artery occlusion were predictors for a poor outcome.

This study has several limitations. We did not include a control group and did also not design the study to evaluate a cause-effect relationship. Therefore, the results preclude new evidence for a cause- and effect relationship. The design is also retrospective. While we acknowledge these shortcomings we would like to point out that this project was not designed to assess the

points mentioned above. Instead, the survey was intended to summarize the number and clinical characteristics of VAD related to neck manipulations in tertiary neurological centers.

In summary, we provide clinical data from 36 patients with vertebral artery dissections due to cervical chiropractic manipulations. Our data point to a yet to be precisely determined substantial risk including death for VAD after neck chiropractic therapy.

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