Raised plasma arginine vasopressin concentrations during cluster headache attacks

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Abstract
To obtain data about peripheral concentrations of arginine vasopressin in head pain syndromes, the plasma arginine vasopressin secretory pattern in 12 adult male patients with cluster headache was evaluated. Blood samples for plasma arginine vasopressin and osmolality determinations were collected before, and at 15, 30, 45, 60, 90, and 120 minutes during a cluster attack. Blood pressure was also monitored. The same sampling was repeated during an asymptomatic period. During cluster attacks, the mean values of plasma arginine vasopressin before an attack (2.3 ± 0.1 ng/l) significantly increased, reaching their peak at 45 minutes (4.8 ± 0.5 ng/l; P < 0.01 vs baseline). No significant variations were found in mean arterial pressure and plasma osmolality. These data suggested involvement of neurotransmitter mechanisms regulating arginine vasopressin secretion and a possible role of arginine vasopressin in vasomotor phenomena accompanying cluster attacks.

Study protocol
The patients were studied on two occasions: during the first two weeks of a cluster period and during a symptom free period, at least two to three weeks after the complete remission of symptoms. During the symptomatic period, blood samples were collected every two hours, starting at 8:00 am. Patients were asked to call medical personnel as soon as they became aware of the onset of the headache attack. Blood samples were then collected at 0, 15, 30, 45, 60, 90, and 120 minutes. The blood sample collected before the start of the attack was considered as baseline. In each patient, blood pressure was recorded at the time each sample was taken and the mean arterial pressure (diastolic pressure + 1/3 pulse pressure) was determined. The duration and severity of pain were also assessed and reported verbally by the patients. The patients rated the severity of their headaches on a five point scale: 0 for no pain, 1 for mild pain, 2 for moderate pain, 3 for severe pain, and 4 for very severe pain. In each patient, the study was repeated at the same times of day, during a symptom free period.

All blood samples were immediately transferred to chilled, siliconised, disposable glass tubes containing aprotinin (250 kIU) and EDTA (7 mg). Blood was centrifuged at 4°C, and the plasma obtained was frozen and stored at −40°C until assayed.

Assays
Plasma arginine vasopressin (2 ml) was extracted and concentrated with small car-
tridges packed with octadecasyl silica (SEP-PAK cartridge): the arginine vasopressin standard was calibrated against the WHO 77/501 standard. The mean recovery of standard quantities added to plasma was 91%. The antisera was highly specific, and had less than 0.01% and 0.014% cross reactivity with oxytocin and vasotocin, respectively. The sensitivity of the assay was 1.2 ng/l. The coefficients of variation within and between assays were 6.1 and 4.4%, respectively. The normal range of our laboratory is 1.2–5 ng/l. In all plasma samples, osmolality was also measured with the freezing point depression method (Fiske osmometer model 330 D; Fiske, Uxbridge, MA, USA).

**STATISTICAL ANALYSIS**

Statistical evaluation of the results was carried out by means of a two tailed Student’s t test and analysis of variance (ANOVA), followed by the Tukey-Kramer multiple comparison test. The arginine vasopressin secretory area was calculated with the trapezoidal rule, after subtracting basal values, and correlation with the severity and duration of pain assessed by the linear regression method.

**Results**

The table and figure show the mean (SEM) data. The mean plasma arginine vasopressin values recorded before the onset of the attacks (2.3 (0.1) ng/l) significantly (F = 4.834; P < 0.01) increased, reaching the highest concentrations at 45 minutes (4.8 (0.5) ng/l; P < 0.01 v baseline, figure). The mean arginine vasopressin secretory areas recorded during cluster attacks (221.8 (35.6) ng/l/min) were significantly (P < 0.01) higher than those recorded during the pain free period (49.9 (8.0) ng/l/min, table). The arginine vasopressin increase occurred in the absence of contemporaneous variations in either plasma osmolality or mean arterial pressure values (F = 0.067 and F = 0.461 respectively; P > 0.05, figure). There was no significant correlation between arginine vasopressin secretory areas and duration (r = 0.159; P > 0.05) or severity (r = 0.113; P > 0.05) of pain.

### Clinical and hormonal data of the patients studied

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<th>Peak (ng/l)</th>
<th>Area (ng/l/min)</th>
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*P < 0.01 v pain free period.

**Discussion**

Our data show that during cluster attacks plasma arginine vasopressin concentrations increase in the absence of nausea and variations in plasma osmolality or mean arterial pressure values, which are known to be potent stimuli of arginine vasopressin secretion. This indicates that in cluster headache stimuli other than osmotic and baroreceptive are responsible for the increase in arginine vasopressin.

Stress has been cited as a possible cause of some hypothalamopituitary dysfunctions. In early studies in particular, increased arginine vasopressin secretion was reported in stressed animals. At present, however, there is no convincing evidence based on further in vivo studies that arginine vasopressin is released in response to stress. It is known that non-osmotic control of arginine vasopressin release undergoes neurotransmitter regulation. Experimental data indicate that serotonine plays a stimulatory part whereas dopamine is mainly inhibitory. Experimental studies suggest that noradrenaline plays a
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modulatory part in arginine vasopressin secretion—that is, high hypothalamic noradrenergic concentrations stimulate, whereas low concentrations tonically inhibit arginine vasopressin release.12 Noceceptive inputs, particularly pain, stimulate arginine vasopressin secretion in humans.13 14 It has been reported that the mechanisms by which noxious stimuli induce arginine vasopressin release from the neurohypophysis involve the A1 noradrenergic cell system, located in the caudal ventrolateral medulla.15 This cell system conveys afferent information from periphery to hypothalamic neurosecretory cells that secrete arginine vasopressin, through catecholaminergic pathways.16 This suggests that activation of a noradrenergic pathway is responsible for arginine vasopressin release during cluster attacks. This hypothesis seems to fit with other indications of a noradrenergic involvement in some hypothalamic endocrine dysfunctions recorded in patients with cluster headache.17 Alternatively, it is possible that the arginine vasopressin increase recorded in our patients may be related to activation of the serotoninergic pathway. It has been hypothesised that in vasomotor headaches the activation of cortical and limbic neuronal pathways leads to the release of serotonin by neurons of the brainstem.18 Thus serotonin may be the triggering factor both of the cascade of the vascular events that characterise vasomotor headaches, and of the arginine vasopressin release.

The pathophysiological importance of the increased concentrations of circulating arginine vasopressin during cluster attacks is at present unclear. Arginine vasopressin is known to be a potent vasoconstrictor.19 It has been postulated that constriction of both arterial and venous tributary vessels reduces the load on the cavernous sinuses to such an extent that pain disappears.20 For this reason, arginine vasopressin might influence the duration and the severity of cluster attacks by exerting its vascular biological effects. In our patients a poor correlation between arginine vasopressin increase and duration or severity of pain was found. This may be due to individual differences in sensitivity threshold to pain and in the severity of the pain. Furthermore, it must be considered that, besides arginine vasopressin, several factors—for example, the integrity of some perivascular sympathetic fibres, circulating catecholamines, and other vasoactive mediators21 22—may condition the vasoconstriction that determines the end of pain.