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Activation of carotid sinus baroreceptors reduces pain sensations evoked by electrical and cold stimulation of human teeth

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Activation of carotid sinus baroreceptors (CSBs) has been shown to have an influence on the perception of pain evoked by electrical stimulation of the skin. The present work was carried out to study to what extent dental pain can be modulated by simultaneous activation of CSBs. In 19 healthy voluntary human subjects, activation of CSBs was induced by application of negative pressure to an air tight collar fitted around the neck of the subjects (neck suction). Dental pain was evoked by electrical stimulation of the tooth (determination of the pain threshold) and by cold stimulation of teeth (ratings of the pain intensity). Neck suction resulted in an elevation of the dental pain thresholds and a reduction of the ratings of the cold-evoked dental pain. The present findings support the suggestion of the interaction of cardiovascular control systems with trigeminal nociceptive systems. *Proc Finn Dent Soc 1989, 85: 409—13*

Key words: Pain modulation, pain ratings, tooth stimulation, dental pain, carotid sinus baroreceptor activation

There is evidence that systems controlling cardiovascular function interact with systems modulating the perception of pain (cf. the review of Randich and Maixner 1984). For example, it has recently been shown that an increased baroreceptor activity in humans is capable of modulating pain perception to electrical stimulation of skin (Elbert et al. 1988, Rockstroh et al. 1988). The present study was undertaken to investigate to what extent electrically and thermally evoked dental pain sensations could be modulated by simultaneous activation of carotid sinus baroreceptors.

Material and methods

The study was carried out on 19 subjects of either sex (aged 21—48 years) with intact upper central incisor teeth. The subjects were sitting in a dental chair. They were informed about the nature of the experiments and they were able to interrupt the experimental session at any stage if they wanted. A training session enabled the subjects to become familiar with all experimental procedures. Two series of experiments were performed.

In the first series of experiments, dental pain thresholds were determined by monopolar electrical stimulation of teeth in 11 of the subjects. A silver electrode covered with an acrylic layer was attached onto the labial surface of one of the upper central incisor teeth with cyanoacrylate glue; the electrical contact was secured with electrode gel. The tooth was kept dry to retain a high electrical resistance between the electrode and gingiva. This resistance was subsequentially controlled several times. The indifferent electrode was attached to the forearm. Rectangular cathodal current pulses of 1 ms duration were applied at a frequency of 1 Hz to the tooth electrode using a constant current stimulator. The intensity of the stimulating current was increased in small steps. For the determination of the dental pain threshold, the subjects were instructed to press a signal button as the intensity was increased to the level that evoked a painful sensation. After determining the threshold the current intensity was reduced to zero.

For activation of carotid sinus baroreceptors (CSBs), a lead collar was fitted around the neck and sealed to be air tight (Eckberg et al. 1975). The collar was connected to a vacuum pump and negative pressures ranging from —35 to —100 mmHg (about 10 mmHg smaller than the maximum pressure that each subject could tolerate in the training session) were applied for one minute. The effectiveness of neck suction was controlled by measuring the blood pressure every 20 s using the Riva-Rocci method and monitoring the heart rate from a standard ECG-recording.

Each experimental session lasting 3 min consisted of 15 consecutive determinations of the dental pain threshold (trials): five before (controls), five during and five after application of neck suction. This sequence was repeated at intervals of 5 min, two to eight times.

In the second series of experiments, the effect of CSB activation on the dental pain sensation elicited by cold stimulation of the tooth was investigated in 11 of the 19 subjects. Long lasting cold stimulation evokes in humans two pain components, i.e., a sharp pain sensation which disappears within a few seconds and a subsequent longer lasting, dull pain sensation (Jyväsjärvi et al. 1989, see Fig. 1D). This might reflect the different response behaviour in the activation of the intradental Aδ- and C-fibres (Jyväsjärvi and Kniffki 1987, see Figs 1A and IB). Cold stimuli were applied to the tooth with an individually adapted copper thermode (diameter: 4.5 mm; Fig. 1C). The surrounding tissues were thermally isolated with dental impression material. With this arrangement it was possible to place the thermode on the same site of the tooth in subsequent trials. The subjects were instructed to continuously rate the magnitude of their pain sensations according to a 50 point category scale (Göbel et al. 1988; 0=no pain, 1—10=very weak pain, 11—20=weak pain, 21—30=moderate pain, 31—40=strong pain, 41—50=very strong pain, >50=intolerable pain). Recordings of the ratings were obtained using a hand-driven linear potentiometer, the output voltage of which was fed to a column of 50 light diodes (visual analogue scale), displayed on an oscilloscope and stored on a magnetic tape. Cold stimuli were applied for 10—20 s; the temperature of the thermode was individually adjusted to evoke a strong first pain sensation. An application of a cold stimulus without neck suction was followed after an interval of 5 min by one with neck suction. This sequence was repeated four times.

Results

Effect of CSB activation on dental pain thresholds

Application of negative pressure, 10 mmHg smaller than the maximum tolerable (range:

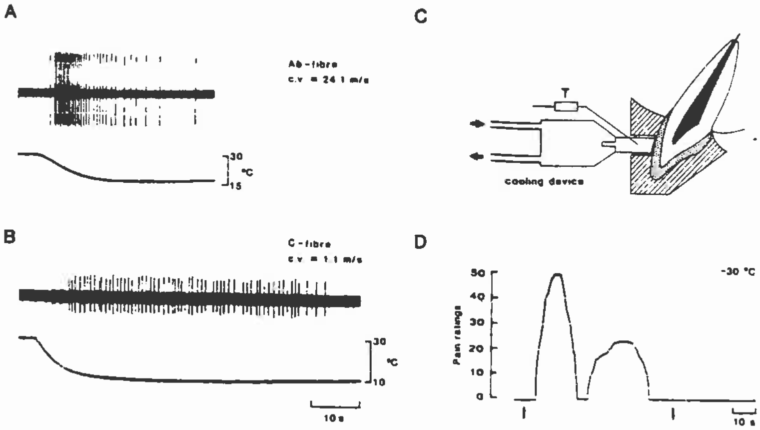

Fig. 1. Responses of an intradental Aδ-fibre (A) and a C-fibre (B) of the cat, identified by their conduction velocities (c.v.) to cold stimulation of the tooth. C: Device used for cold stimulation of human teeth. The tooth crown was thermally isolated. T indicates the measurement of the thermode temperature. D: Pain ratings evoked by cold stimulus applied at a thermode temperature of —30°C.

—35 to —100 mmHg), to the neck of the subjects resulted in a transient decrease in the systolic blood pressure of about 10 mmHg and a slight transient (duration: 5—10 s) reduction in heart rate.

The dental pain thresholds before application of neck suction (control trials) were remarkably stable in each subject; the individual thresholds ranged from 14 to 84 μA. During neck suction, in all but one subject, elevated dental pain thresholds were observed. Changes in the dental pain thresholds of one subject are shown in Fig. 2. During application of neck suction of —60 mmHg the pain threshold slowly increased to 1.3-fold of the control values. After neck suction was terminated, the post-suction pain thresholds (6 trials in this case) slowly decreased to control values. This time course of the changes of the dental pain thresholds was similar in subsequent sessions.

In six of the ten subjects the post-suction thresholds returned to the control values, but in four of the subjects they remained elevated and returned to the control level in the resting period before the next session. Averaged across all subjects and trials, the pain thresholds during neck suction were 10 % higher than the control values.

Effect of CSB activation on cold evoked dental pain ratings

In each subject cold stimulation of the tooth at a given intensity evoked a rapidly increas-

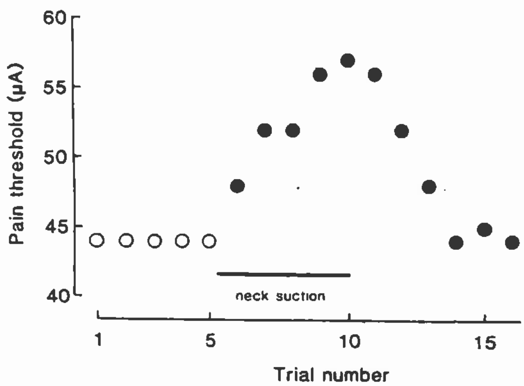

Fig. 2. Pain thresholds to electrical current pulses applied to an upper central incisor tooth of one subject during one session: control trials before (trials 1—5; open circles), during (trials 6—10; filled circles) and after (trials 11—16; filled circles) neck suction. The application of neck suction of —60 mmHg for 1 min is indicated by the bar.

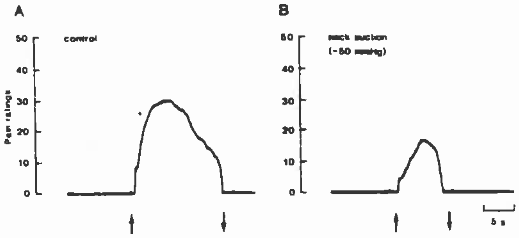

Fig. 3. Pain ratings evoked by cold stimulation of an upper central incisor tooth of one subject before (A) and during neck suction (B).

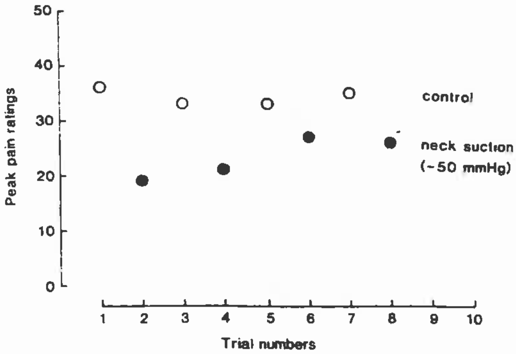

Fig. 4. Peak ratings of the pain sensation evoked by cold stimulation of an upper central incisor tooth of one subject. Every control trial (open circle) was followed by a trial with simultaneous neck suction (filled circle).

ing, sharp pain sensation with a short latency and duration. An example of the ratings of one subject is shown in Fig. 3A. In Fig. 3B the pain ratings of the same subject in response to an identical cold stimulus during neck suction are shown. The pain ratings were reduced as can be seen from the peak pain rating, which was reduced from strong to moderate pain. In this case also the rate of increase and the duration decreased.

In Fig. 4 the peak pain ratings of a complete sequence of trials for one subject are shown. The peak pain ratings during neck suction (filled circles) were clearly smaller than the respective ratings without simultaneous neck suction (open circles). For this subject the difference between pain ratings with and without neck suction became somewhat smaller in repeated trials.

In general, in all subjects the peak pain ratings were reduced from strong to moderate pain during neck suction. However, interindividual differences were observed.

Discussion

The results of the present study demonstrated an elevation in the dental pain thresholds and a reduction in the peak pain ratings of the cold-evoked dental pain sensation during simultaneous activation of carotid sinus baroreceptors evoked by neck suction. On the other hand, it has been shown that neck suction has no effect on acoustic thresholds, and suction on the leg has no influence on the dental pain thresholds (unpublished results). All these findings suggest that increased activity of carotid sinus baroreceptors might reduce dental pain sensations by a specific central effect.

Elbert et al. (1988), using a different methodological approach, reported that the electrical pain thresholds of the skin were elevated during simultaneous neck suction in subjects with arterial hypertension, but that in normotensive subjects a reduction in the pain thresholds was observed. In the present study, however, no obvious correlation of the amount of increase in pain thresholds with blood pressure was observed. Only one subject with normal blood pressure showed no change in dental pain thresholds during neck suction. The discrepancy between the present results and those of Elbert et al. (1988) remains currently unexplained. There might be a difference in the susceptibility of the somatic nociceptive systems compared to the trigeminal ones with respect to activation of CSBs.

The possible specific central mechanisms for the reduction of dental pain by activation of CSBs remain to be explored (cf. the review of Randich and Maixner 1984). One central region which might play a role in the interaction between the CSBs and the nociceptive systems has recently been found in the medial region of the cat's thalamus (Brüggemann et al. 1989, Vahle-Hinz et al. 1989). Particularly, the activity of some neurones in the mediodorsal nucleus and in the periphery of the ventrobasal complex was modulated by the altered activity of CSBs.

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