SHORT REPORT

Carotid brainstem reflex myoclonus after hypoxic brain damage

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Abstract

A patient comatose after acute anoxia developed bilaterally synchronous, periodic myoclonic jerks most prominently in the bilateral upper limbs. Although the myoclonus seemed to occur spontaneously, electrophysiological studies showed that the myoclonic jerks correlated in timing and size with arterial pulses, and was suppressed by massage over the carotid sinus. It is proposed that the present myoclonus is a variant of brainstem reflex myoclonus in which arterial pulses served as intrinsic trigger stimuli via the carotid sinus and the medullary reticular formation.

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Bilaterally synchronous myoclonic jerks sometimes follow acute hypoxia, and carry a poor prognosis when myoclonus is prolonged in comatose patients especially with generalised seizures.^{1,2} Even if those patients recover from coma, they may develop intention myoclonus as a sequel.³ Although posthypoxic myoclonus arises in the brainstem spontaneously or reflexively,⁴⁻⁶ it varies in clinical manifestations and probably in generating mechanisms. Here we report on an acute posthypoxic patient who manifested seemingly spontaneous myoclonic jerks that were actually triggered by intrinsic periodic stimuli—namely, arterial pulses.

Subjects and methods

PATIENT REPORT

A 69 year old man was resuscitated from acute cardiopulmonary arrest but remained comatose. An ECG showed normal sinus rhythm with occasional premature contractions. Respiration was artificially supported, and blood pressure was maintained by administration of catecholamines. On neurological examination, he showed no purposeful movements and remained unresponsive to any external stimuli. The pupils were fixed and mildly dilated. The oculocephalic, corneal, and ciliospinal reflexes were all lost. The deep tendon reflexes and plantar responses were not elicited. Several hours after the arrest, he developed seemingly spontaneous, periodic myoclonic jerks, promi-

nent in the bilateral upper limbs and less prominent in the axial muscles. The jerks were bilaterally synchronous in the upper limbs, primarily resulting in extension movements of both wrists. Neither the soft palate nor the tongue muscle was involved. The myoclonic jerks occurred almost regularly at a rate of around 1 Hz. Interestingly, each jerk seemed to follow each QRS complex appearing on the ECG monitor, which urged us further to study the myoclonic jerks in this patient. When rapid atrial fibrillation developed on the third hospital day, the myoclonic jerks were no longer visible. He died on that day due to medically intractable hypotension.

On the first and second postarrest days, multichannel surface EMGs with simultaneous ECG recordings and jerk locked back averaging were obtained by NEUROPACK 8 (Nihon Koden, Tokyo). Surface EMGs were recorded by placing a pair of disc electrodes about 4 cm apart over each muscle belly. Examined muscles included sternocleidomastoid, masseter, pectoralis major, abdominal, biceps brachii, triceps brachii, wrist extensors, and wrist flexors. The recording was performed in various settings of sensitivity and paper speed (30 to 100 mm/s) with a band pass filter of 50 to 1000 Hz. To study possible stimulus sensitivity of the myoclonic jerks, several kinds of external stimuli were delivered during the recording. In the EMG-ECG record, we measured the time intervals between the onset of successive myoclonic EMG discharges, and the R-R intervals of normal heartbeats, as shown in the figure A. To investigate whether the periodicity of the myoclonic EMG discharge would correlate with the ECG rhythm or not, a regression analysis was applied to those two time intervals. Arterial pulse waves were directly recorded from a catheter placed in the radial artery simultaneously with ECG but EMGs. In jerk locked back averaging, EEGs obtained from the electrodes placed at C3, C4, and Cz (international 10-20 system) were averaged by employing the onset of the rectified myoclonic EMG activity from the left wrist extensors as a trigger.⁷ A filter setting of amplifier for EEG recording was 0.1-500 Hz.

To estimate the latency of carotid arterial pulses after the ECG R waves, we examined 33 elderly subjects (mean age, 69.2 years; 18 men and 15 women) by ECGs and Doppler

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(A) Simultaneous recording of surface EMGs and ECG. The record from the left wrist extensor muscles shows myoclonic EMG discharges that abruptly arise from the baseline and then gradually decline, intermingled with smaller background EMG activity. There is concomitant EMG activity in the left wrist flexors and less often in the abdominal muscles (ignore ECG artifacts on the abdominal muscle trace). Vertical thin lines in the uppermost trace show the onset of each myoclonic EMG discharge, and numerals indicate time intervals in seconds between the two successive EMG discharges measured at their onsets. Similar lines in the ECG trace are given only for R waves of sinus heartbeats, and numerals represent time intervals in seconds between them (R-R intervals). Arrow heads indicate premature contractions. Note that myoclonic EMG discharges always accompany the R waves of ECG except for those of premature contractions. (B) The linear relation between the R-R intervals of ECG and the time intervals of myoclonic EMG discharges. Examples of sampling are shown in (A). It indicates that the regular one to one response of each myoclonic jerk to the preceding sinus heartbeat was maintained throughout the record. (C) Effects of carotid sinus compression on the myoclonic jerks. Whereas the neck over the right carotid sinus was manually compressed, myoclonic EMG activity in the wrist extensors was markedly reduced on both sides. (D) The latency for the onset (L1) and the peak (L2) of the carotid arterial pulse (CP) after the R wave of ECG, as measured by Doppler ultrasonography. The illustrated data are from a representative single subject (man, aged 75 years), showing L1 of 72 ms and L2 of 192 ms.

ultrasonography (COREVISION SSA-350A, Toshiba, Tokyo). When they underwent a screening study for possible atherosclerosis, ECGs and pulse waveforms at the right carotid sinus were simultaneously recorded, yielding data on the onset and peak latency of carotid pulses after the ECG R waves.

Results

Bilateral wrist extensors showed bilaterally synchronous myoclonic EMG discharges with abrupt onset, followed by a gradual decline in amplitude over a period of 200–500 ms (figure A and C). The forearm flexors showed concomitant EMG discharges, indicating co-contraction of the antagonist muscles. These predominant myoclonic EMG discharges were intermixed with small, irregular background EMG activity. Myoclonic EMG activity was also found, though less prominently, in the axial and proximal limb muscles. There was no EMG activity in the cranial muscles.

An unusual characteristic of the myoclonic EMG activity was that, in the normal sinus rhythms, the R wave of ECG preceded the onset of each EMG discharge in a one to one manner, with the mean latency of 200.7 (SD 6.2) ms. Although the myoclonic EMG discharges did not follow premature contractions, they were slightly increased in amplitude when accompanied by the sinus heartbeats immediately after premature contractions (figure A). In the whole EMG-ECG record, 195 normal sinus heartbeats and 43 premature contrac-

tions were identified, disclosing a mean R-R interval for the sinus heartbeats of 0.83 (0.25) s. Out of the 196 myoclonic EMG discharges identified in the same record, all but one exclusively followed the sinus heartbeats with mean EMG intervals of 0.83 (0.23) s. The time intervals of the myoclonic EMG discharges clearly showed a temporal correlation with the R-R intervals of ECG, supporting the one to one response of each myoclonic jerk to the preceding sinus heartbeat (figure B). In the direct arterial pressure measurements, systolic pressure was lower with premature contractions, and higher with the normal beats immediately following premature contractions (postsystolic potentiation), than with normal sinus beats. Therefore, the size property of the present myoclonus—that is, absence with the premature heartbeat and enhancement with the subsequent normal heartbeat, inferred that the present myoclonus was sensitive to a magnitude of arterial pulse pressure.

Massage over the carotid sinus on either side markedly suppressed the myoclonic jerks bilaterally (figure C). During the massage, heart rates and blood pressure remained unchanged. Conversely, a gentle tapping over the carotid sinus occasionally provoked myoclonic jerks (not recorded), although similar stimuli to other cervical areas caused no effects. Other somatosensory, pain, photic, or auditory stimuli never elicited any myoclonus and had little influence on the existing myoclonic activity. The conventional EEGs showed low ampli-

tude, diffuse slow waves without spikes or burst activity. Jerk locked back averaging of EEGs failed to demonstrate any spike activity preceding the myoclonic EMG discharge. Brainstem auditory evoked potentials showed only the first and second peaks bilaterally, and somatosensory evoked potentials disclosed clear peaks at each Erb's point but no distinguishable cortical responses.

In the 33 elderly subjects studied with ECGs and Doppler ultrasonography, the mean latency for onset and peak of the carotid arterial pulse after the ECG R wave was 74.4 (12.4) ms and 179.2 (43.5) ms, respectively (figure D).

Discussion

Clinical features in the present patient with acute anoxia, including the absence of brainstem reflexes and evoked potentials, indicate a severe brainstem dysfunction at and above the level of the pons. As discussed below, we propose that the present myoclonus is a unique variant of brainstem reflex myoclonus.^{4 5 8 9}

The present myoclonus showed not only a fixed temporal relation with cardiac rhythm but also a probable correlation in size with arterial pulse pressure. Arterial pulse pressure is sensed by baroreceptors at the aortic arch and carotid sinus, and such information physiologically provides a feedback to regulate the cardiovascular system. The fact that tapping over the carotid sinus occasionally elicited the myoclonic jerks indicates the role of the carotid sinus in generating the myoclonus. Based on this, it is postulated that the present myoclonus was elicited when the magnitude of phasic stimuli to the carotid sinus, like arterial pulses or tapping, exceeded a given threshold. If this is the case, the estimated latency for the onset of myoclonic EMG discharge after the stimuli should fall between 20 and 130 ms, taking into account the mean onset and peak latency of the carotid pulse after the R wave in elderly subjects. Considering the abortion of the present myoclonus when arterial pressure was diminished in premature contractions, the trigger point would be near the peak, rather than the onset, of the carotid pulses. Hence the actual latency for the reflex is estimated to be several 10s of ms, which is consistent with the latency reported in brainstem reflex myoclonus.^{4 5 9} The relatively long duration of the myoclonic EMG activity and the absence of

spikes in the jerk locked back averaging exclude cortical origin of the present myoclonus. The inhibition of myoclonic activity by massage over the carotid sinus could result from tonic stimuli interfering with the reflex mechanisms.

Afferent inputs from the carotid sinus travel through the glossopharyngeal nerve, terminating in the vasomotor centre, probably situated in the medullary reticular formation. The medullary reticular formation interconnects with motor and sensory systems,¹⁰ and is suggested to play an important part in generating myoclonus.¹¹ Interestingly, a part of the brain stem is involved in the regulation of both vasomotor and motor control in rats,¹² suggesting that even autonomic information communicates with the motor system in the reticular formation. Although the brainstem function seemed to be severely impaired in the present patient, the caudalmost medulla and the spinal cord, the minimal possible central nervous components supposed to evoke the present myoclonus, could partly retain their function. To our knowledge, this is the first report of a patient whose apparently spontaneous myoclonus is caused by autonomic afferents from the carotid sinus.

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