SHORT REPORT

Orthostatic mesodiencephalic dysfunction after decompressive craniectomy

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J Neurol Neurosurg Psychiatry 2007;78:430–433. doi: 10.1136/jnnp.2006.099242

An extreme syndrome of the trephined after decompressive craniectomy is reported here. The most extensive clinical syndrome observed was established over 4 weeks and consisted of bradypsychia, dysarthria, and limb rigidity with equine varus feet predominating on the right. The syndrome was aggravated when the patient was sitting with the sequential appearance over minutes of a typical parkinsonian levodopa-resistant tremor starting on the right side, extending to all four limbs, followed by diplopia resulting from a left abducens nerve palsy followed by a left-sided mydriasis. All signs recovered within 1–2 h after horizontalisation. It was correlated with an orthostatic progressive sinking of the skin flap, MRI and CT scan mesodiencephalic distortion without evidence of parenchymal lesion. Brain stem auditory evoked potential wave III latency increases were observed on the right side on verticalisation of the patient. EEG exploration excluded any epileptic activity. Symptoms were fully recovered within 2 days after cranioplasty was performed. The cranioplasty had to be removed twice due to infection. Bradypsychia, speech fluency, limb rigidity and tremor reappeared within a week after removal of the prosthesis. While waiting for sterilisation of the operative site, the symptoms were successfully prevented by a custom-made transparent suction-cup helmet before completion of cranioplasty.

Large decompressive craniectomies are performed to reduce secondary insults related to intracranial hypertension generated by cerebral oedema. Few complications have been reported and generally referred to as the trephined syndrome or sinking skin flap syndrome. Although focal and global cerebral dysfunctions after craniectomies have been extensively studied, our understanding of the aetiology is still limited. Our report, of a particularly severe syndrome of the trephined with an orthostatic-induced mesodiencephalic dysfunction after decompressive craniectomy that fully and rapidly recovered after cranioplasty, might provide new perspectives.

CASE REPORT

A 32-year-old woman restaurant tender presented with sudden headache and three inaugural seizures. On admission, her mental status was normal and no focal neurological deficits were found. The native CT scan demonstrated a right sylvian subarachnoid haemorrhage Fischer grade 3. The angio CT scan revealed a ruptured aneurysm on the right sylvian bifurcation and a mirror aneurysm on the left side. The two aneurysms were further studied by digital subtraction angiography. The sylvian bifurcation aneurysm on the right side was clipped on the same day. The postoperative neurological examination was normal. After 1 week, the patient rapidly became confused and a severe vasospasm was diagnosed on the right sylvian artery by digital subtraction angiography. Hyperhydration and hypertensive treatment was started and balloon angioplasty of the right

M1 segment was performed. Despite the treatment, the patient remained confused. No transcranial doppler or cerebral blood flow studies were performed at that stage, but right hemispheric oedema with significant midline shift was demonstrated on CT. A decompressive hemicraniectomy was performed on the right side. The patient recovered to a normal neurological status after 4 days.

During the following month the patient complained first of headaches, fatigue and felt depressed. A resting tremor appeared in the evening and progressively increased. It started on the right side before extending to all four limbs and was increased by emotions and stopped by voluntary movements and sleep. Concomitantly, the skin flap depressed progressively. All symptoms disappeared on the day after cranioplasty was performed. After 1 month, the Palacos artificial bone flap (Heraeus Kulzer, Hanau, Germany) had to be removed because of infection. During the following weeks, clinical symptoms progressively reappeared. The first sign observed was again an orthostatic-induced Parkinson-like resting tremor. Dihydroxy-3,4 Phenyl-3 L-alanine and treatment with anticholinergic drugs failed to control the tremor. The tremor systematically started on the right side, increased and progressively extended to all four limbs when the patient was seated. It consistently and progressively decreased as soon as the patient lay in a horizontal position. Other signs then successively appeared. Speech fluency got slow and progressively inaudible, rigidity and varus equine foot installed on the right side and an orthostatic-induced diplopia due to left abducens palsy and orthostatic-induced left mydriasis, were observed. MRI studies were performed showing mesencephalon distortion but no lesion in the basal ganglia or brain stem parenchyma (fig 1). EEG studies in the horizontal position were performed. Discrete flap amplitudes were observed (fig 2). At 1 min after transition to a sitting position, a 5 Hz rhythmic activity with increasing amplitude was observed, mainly around temporal electrodes (fig 3). We attributed this observation to temporal muscle tremor. Simultaneously, the ECG revealed an increase in movement artefacts due to progressively increasing tremor of the chest wall. The video recording showed gradually increasing generalised resting tremor of 5 Hz of the head and limbs. No epileptic spikes were ever observed even with periodic light-flash stimulations up to 30 Hz.

Brain stem auditory-evoked potential (BAEP) studies in the horizontal (fig 4A) and vertical positions (fig 4B) demonstrated a significant increase in wave III latencies on the right side in the vertical position. Despite difficulties in formally identifying the fifth wave with precision, a bilateral wave V latency increase was convincingly observed in the vertical position.

After a second cranioplasty 3 months later, symptoms progressively and completely disappeared within a few days.

After 4 months, while swimming in a pool, the scar reopened and the second cranioplasty became infected again and needed

Abbreviation: BAEP, brain stem auditory evoked potential

Figure 1 Upper left corner: CT scan, three-dimensional reconstruction of the skull showing the bone defect. T2-weighted MRI study performed after the 2nd decompressive craniectomy showing a mesodiencephalic distortion and right tempo-polar ischaemic after-effects. No evidence of basal ganglia or midbrain lesion is visible. Upper right corner: coronal section; lower left corner: axial section through midbrain; lower right corner: axial section through basal ganglia.)

to be removed. Tremor reappeared after 1 week and was successfully treated with a custom-made transparent suction-cup helmet that prevented skin flap sinking. Single-photon emission CT studies in the horizontal and vertical positions, BAEP, visual evoked potentials, motor and sensitive-evoked potentials in the horizontal and vertical positions were performed and no orthostatic modifications were observed. It must however be emphasised that clinically only a very discreet orthostatic-induced tremor could be observed. Interestingly, the tremor could also be immediately interrupted by transcranial magnetic stimulation of the motor cortex area on the right side.

A third cranioplasty was performed and the patient again recovered completely.

Figure 2 EEG recorded in the horizontal position illustrating discrete flap amplitudes.

DISCUSSION

Craniectomies resulting from trauma, violence or surgery for tumours, infections or brain decompression are usually well tolerated. Some patients suffer symptoms such as headaches, dizziness, mood changes or seizures that were described and defined as the syndrome of the trephined by Grant and Norcross in 1939.¹ Gardner² then reported clinical improvement after cranioplasty completion and Yamaura and Makino³ reported the association of the syndrome with sinking of the skin flap. More recently, Schiffer *et al*⁴ reviewed the literature and reported five cases with progressive focal neurological deterioration after craniectomy that were improved by cranioplasty justifying cranial vault reconstruction as a therapeutic procedure.⁴ Kumar *et al*⁵ described the worsening of left hemiparesis in the sitting position and sunken skin flap in the right frontoparietal region which improved with cranioplasty. Gootlob *et al*⁶ reported a case of extraocular motility disturbance, consistent with a midbrain syndrome, associated with a large skull defect that fully recovered after cranioplasty.

The case reported here is most probably an extreme case of syndrome of the trephined that worsened progressively over 3 months and resulted in the constellation of signs and symptoms described above.

The first symptoms of headache, fatigue and depression are part of the classical definition of the trephined syndrome and many theories have been proposed to explain the aetiology. It has been proposed that pathogenesis of the syndrome could be

Figure 3 EEG recorded in the vertical position with periodic light flash stimulation at 30 Hz showing no epileptic activity and confirming orthostatic tremor at 5 Hz.

divided into three different components: (1) cerebrospinal fluid hydrodynamic changes; (2) cerebrovascular or haemodynamic changes; (3) metabolic changes. It has been shown that patients with large cranial defects have an increased intracranial pressure, decreased cerebrospinal fluid movements and altered perfusion owing to modifications of the intracranial compliance. Decrease in the cerebral blood flow underneath the cranial defect has been measured, and global metabolic alterations that are more prominent on the side of the lesion have been observed.⁷⁻¹⁴

Parkinson's syndromes are occasionally observed with supratentorial tumours sparing the basal ganglia,¹⁵ normal pressure hydrocephalus¹⁶ or chronic subdural haematomas¹⁷ all resulting in compression, distortion or hypoperfusion of the basal ganglia. Efficacy or failure of levodopa treatment may be related to the level of the functional lesion along the nigrostriatal axis. Patients with altered dopaminergic receptors

in the striatum might not respond to pharmacological treatment, whereas those with compromised nigrostriatal outflow but intact basal ganglia would.

Biomechanics of the brain tissue, hypothetically play a substantial role. With intact skull there is no measurable pressure gradient across brain mantle even in cases with disturbed CSF flow. With open craniectomy such a pressure gradient is natural. In the horizontal position transmantle pressure gradient is positive (ie, ventricular pressure is positive and cranial subarachnoid pressure remains at the atmospheric level). It may encourage ventricular dilatation and hydrocephalus. In the upright body position, when CSF pressure is negative, transmantle pressure gradient also becomes negative. Therefore, the brain sinks, structures shift and probably neural routes are stretched.¹⁸ It could lead to distortion of the diencephalon as observed on the MRI when the patient was in the horizontal position which further increased in the vertical position with sinking of the skin flap and subsequent collapsing of the brain affecting, first, the right side and then extending to both striates explaining the pharmacologically resistant Parkinson tremor. Distortion of the major white matter tracts could be evaluated by diffusion tensor imaging that was unfortunately not performed in our patient. Similarly, the downward and leftward drift of the brain stem would cause herniation-like signs. The stretching of the cranial nerves over the edge of the petrous bone or the tentorium cerebelli would explain the abducens palsy and the mydriasis on the left side. The stretching of the left lateral lemniscus would explain the wave III latency increase observed on the BAEP. The orthostatic displacement of structures, indirectly observed here, could be visualised using an upright MRI system.

No irreversible anatomical lesion in the diencephalon and brain stem could be seen on MRI and no persistent signs or symptoms after cranioplasty, as might be expected after severe

Figure 4 Brain stem auditory-evoked potentials recorded 3 months after the 2nd decompressive craniectomy (A) in a horizontal position and (B) in a sitting position. Wave III latency is significantly increased after right ear stimulation, indicating a lesion between the bulbar nucleus and the lateral lemniscus. Wave V latencies were bilaterally increased in the vertical position compared to wave V in the horizontal position suggesting a metencephalic-mesencephalic lesion.

and long-lasting focal hypoperfusion. Subsequently, we propose that cerebral collapse, and distortion induced stretch of fibre bundles and cranial nerves, might cause fully reversible mechanical axonal dysfunction without structural destruction enabling rapid normalisation of neurological examination on correction by cranioplasty.

ACKNOWLEDGEMENTS

We would like to thank Dr Marek Czosnyka for constructive comments on the manuscript.

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Competing interests: None declared.

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Received 1 June 2006

Revised 5 October 2006

Accepted 25 October 2006

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