Unexplained Cardiac Arrest During Closure of Craniotomy: Case report and review of literature

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Abstract:
Hypotension and bradycardia after application of suction to a subgaleal drain, or stimulus inside or outside the skull, have been reported in the medical literature. The commonly reported occurrence is stimulation of the Trigeminal nerve along its distribution and is the main factor that sets off the whole reflex arc through the Vagus nerve ending in a series of serious hemodynamic changes that institute severe bradycardia, asystole and severe hypotension. Another less common but possible pathology caused by a suction drain is Pseudo-Hypoxic Brain Swelling (PHBS).

We report a case of transient cardiac arrest after the application of theatre suction to a subgaleal drain at the closure of an uneventful craniotomy and discuss the possibilities as well as review the literature.

Key words: Trigeminocardiac Reflex, Pseudo Hypoxic Brain Swelling, subgaleal suction, craniotomy, cardiac arrest

Case Report:
A 50-year-old male presented for investigation of gradual loss of vision. Visual acuity of the right eye was 3 m and the left eye 1.5 m with a sudden deterioration of vision of the left eye over the previous five days. He had no symptoms of headache or vomiting, no history of cardiovascular disease and his baseline ECG was normal. Ophthalmic examination showed a bilateral disc pallor (atrophy), bitemporal hemianopia, and visual acuity of 6/60 with good ocular movements. A computed tomography scan of the head showed a mass within the pituitary fossa, extending up to the third ventricle and pressing upon the optic chiasma-the appearance was suggestive of pituitary macroadenoma. Blood investigations revealed normal endocrine status, and a diagnosis of non-functioning pituitary macroadenoma was made.

The patient underwent an uneventful transphenoidal excision of this adenoma but a postoperative computed tomography scan of the head showed incomplete tumor excision and so, ten days following the first surgery, he was rescheduled for a left pterional craniotomy and tumor excision.

On presentation to the operating room, standard monitors included the left radial artery catheter. General anesthesia was induced with sodium thiopentone (4 mg/kg-1) and fentanyl (8 mcg/kg-1) and neuromuscular blockade was achieved with pancuronium (0.1 mg./kg-1). Anesthesia was maintained with 40% oxygen: air mixture and isoflurane. Following endotracheal intubation, ventilation was controlled to sustain ETC02 of 35 mmHg. Phenytoin (1.0 g) was given intravenously over 20 minutes.

The surgery proceeded uneventfully. Estimated blood loss was 600 ml and urine output was 2,350 ml during the course of surgery. The intravenous fluid replacement consisted of 3,500 ml normal saline and 500 ml hydroxyethylstarch. At the beginning of the dura closure, paracetamol (2 g) was given intravenously and morphine (4.5 mg) was given subcutaneously. During the wound closure a subgaleal drain was inserted and the system was temporarily connected to the field suction. After applying negative pressure to the drainage system, the heart rate and arterial pressure dropped to 29 beats per minute and to 44/17 mmHg respectively and the patient quickly proceeded to asystole. Anesthetics were discontinued, the lungs were ventilated with 100% oxygen, 1 mg of adrenaline (1:1000) was given intravenously twice at one minute intervals along with intravenous ephedrine.

A full recovery of his hemodynamics plus an overshoot of arterial pressure took less than five minutes. In the meantime the surgeon was requested to re-open the wound and the cranium but there were no significant findings. Blood investigations were done twice - half an hour as well as two hours post-incidence - which showed an insignificant metabolic acidosis as compared with the pre-incident analysis (pH 7.40, 7.36 to 7.49 respectively) and as the standard bicarbonate was 19.5, so 50 ml of sodium bicarbonate was infused. Other parameters such as pO2 and pCO2 were maintained within average values.

Two hours later - at the conclusion of the surgery - and as
extubation was planned, the patient began to move his limbs and opened his eyes on command but suddenly developed generalized tonic clonic seizure. Thiopentone and neuromuscular blocking drugs were given intravenously along with 100 ml of mannitol 20% and the patient was then transferred to the intensive care unit for post-operative ventilation and further management.

As expected in the immediate post-operation period, a brain CT scan showed mixed density changes on the left temporal lobe and a small amount of blood and air within the pituitary fossa and the left sylvian fissure (Figure 1a). Also, bilateral symmetrical low density changes were noted in the putamen, globus pallidus and thalamus. This led to the obliteration of the details of the internal capsule and moderate left hemispheric edema, which in turn, led to compression of the ipsilateral ventricle (Figure 1b) and obliteration of the surface markings in the top sections of the left cerebral hemisphere (Figure 1c).

Discussion:

The use of an epidural or subgaleal drain following a craniotomy is a widespread practice in neurosurgery. Neurosurgeons use it almost on a daily basis and consider it safe and risk free although there have been many reports of bradycardia and arterial hypotension associated with those applications and other surgical handling in and outside the cranium[1-6].

Intracranial hypotension leading to cardiac arrest was reported by Alfreys et al[7] in a patient with hydrocephalus following rapid drainage of cerebrospinal fluid (CSF). They postulated that this occurs as a consequence of rostral migration of the brain with a subsequent application of pressure on the hypothalamus.

Van Roost et al[8] investigated patients having non-awakening and dramatic neurological deterioration after uneventful neurosurgical procedures. They described hypoxic brain swelling in CT/MRI of patients as a result of intracranial hypotension related to negative suction drain. They called this condition Pseudo-Hypoxic Brain Swelling (PHBS) - as hypoxemia was ruled out as a cause of this condition - with graded generalized brain edema (mild, moderate and severe) and inclination to affect basal ganglia and thalamus in most of the patients. Most of the patients in their study showed brain stem manifestations (mydriasis, posturing and not awakening) plus seizures in six of them. Hemodynamic changes coupled with mydriasis were seen in one patient only.
In our patient the bone flap was attached with BioGlue® (Cryolife Inc). BioGlue® Surgical Adhesive is purified bovine serum albumin and glutaraldehyde mixed in a 4:1 ratio. It was first approved for use in the United States in 1999 and was primarily intended for cardiac and vascular repair as an adjunct to provide hemostasis. The potential and late toxic effects on tissues of BioGlue® have been reported(9-10) but there are no reports of an immediate immune response to its application, despite the possibility of such a reaction. BioGlue® was not used in the first surgery for this patient and this might exclude the possibility of an anaphylactic reaction after a second exposure. In addition, as it provides a “water tight” seal, BioGlue® might have blocked the transmission of subatmospheric pressure to the inside of the cranium. The postoperative CT scan did not show global cerebral hypoxia/swelling but it did show bilateral low density changes in the basal ganglia and the thalamus.

Apart from the generalized seizure, no brain stem manifestations were noticed but all of these cannot preclude or include with certainty the possibility of PHBS, and a milder form of this phenomenon could have been a part of the continuum of effects of intracranial hypotension because of the application of suction. As it was detected early and treated, the patient had an uneventful recovery.

Another mechanism that might explain the events in our patient, is Trigemino-cardiac Reflex (TCR). This is a well-recognized phenomenon consisting of bradycardia, arterial hypotension, apnea, and gastric hypermotility during ocular surgery (Oculocardiac reflex) or upon mechanical stimulation in the distribution of the trigeminal nerve that primarily provides a sensory supply to the face, scalp, and mucosa of the nose and mouth. Afferent impulses travel through the sensory branches of the Trigeminal nerve to the main sensory nuclei in the floor of the fourth ventricle, which is connected to the motor nucleus of the Vagus nerve through short interneuron fibres. Stimulation and deformation of the scalp nerve endings because of the subatmospheric pressure of suction may have triggered this response. The operating theatre suction and the silicone closed wound drain can generate a subatmospheric pressure of -400 mm.Hg and -120 mm.Hg, respectively. The hypotension and bradycardia - which quickly progressed to asystole and responded to judicious doses of adrenaline and ephedrine - was probably the result of the late discontinuation of the negative pressure stimulus pending the reopening of the wound.

The edema of the left cerebral hemisphere (site of surgery) might be explained by the augmentation of the regional cerebral blood flow (rCBF) emanating from post TCR activation of sympathetic nerves. The good outcome seen in this patient is probably a part of the neuroprotective mechanism this reflex offers through activation of other pathways of the brain(11,12).

In summary, TCR is the most favored mechanism for the hemodynamic instability that occurred in our patient. Although vacuum drainage systems are usually devoid of adverse effects, caution needs to be exercised during their application. Vigilance by the anesthetist during their application will lead to early detection of these two life-threatening consequences.

**Conclusion:**

After ruling out any technical or pathologic causes, we have come to the conclusion that the development of this serious hemodynamic episode may have been caused by the application of surgical field suction to the subgaleal drain - which is the only factor that conforms to those published in the medical literature. The entire intraoperative course was otherwise uneventful, and we have thoroughly examined and analyzed the case report and found no other logical and/or justifiable explanation for what happened to this patient.

We hope that this case will aid in the further study and analysis of similar cases worldwide and will help to shed light on the many possible unknowns that we have yet to learn.

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**References:**


