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Review Article

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Surgical Device for Cerebral Herniation Galena

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Abstract

Procrastination is a self-defeating pattern of behaviours, it may also be perceived as having a psychological benefit, particularly for perfectionists since it shields the person from feelings of shame, guilt, and fear of failing. Devoting energy to other chores, such as organizing or cleaning, instead of disagreeable labour helps procrastinators avoid feeling unproductive, even though they will eventually pay a price for it. Academic procrastination, which is classified as a domain-specific behaviour, describes students' propensity to put off or postpone finishing assignments that have a set deadline, such as writing an essay, doing their homework, or preparing for an exam.

Keywords: Secondary School Students, Procrastination, Social Anxiety, Stress and Resilience.

The design of this device requires neurosurgical, neurophysiological, bioengineering and computer engineering skills

Cerebral herniation is a pathological phenomenon, due to an increase in intracranial pressure, which causes abnormal protrusion of brain tissue putting the patient's survival at risk. Brain herniation occurs when brain tissue, cerebrospinal fluid, and blood vessels are displaced (or pressed) from their usual position in the head. If this occurred during surgery, the success of the surgery would also be called into question. Brain herniation, as a whole, represents a potentially life-threatening event.

Often the main cause of cerebral herniation is cerebral edema i.e., an alteration of the CNS from accumulation of intracellular and extracellular fluids resulting in increased cerebral volume and pressure. Brain hernias are also the most common side effect of brain tumors (e.g., primary brain tumors such as meningiomas and glioblastomas and/or metastatic) but can also be caused by: abscess, hydrocephalus, stroke, etc. Or, again, be a consequence of cranial neurosurgery.

The most common symptoms are: progressive loss of consciousness, loss of brainstem reflexes, irregular breathing, cardiac arrest, coma, respiratory arrest, etc.

From an anatomical point of view, brain hernias can occur at any level of the CNS, for example, Arnold- Chiari malformations are associated with herniation of the cerebellum.

In light of the serious emergency that this pathology represents in the neurosurgical field and in view of the fact that there are currently no surgical techniques that can intervene with less invasiveness than decompressive craniectomy, I have thought about the realization of a helmet as a device for cerebral herniation capable of reducing swelling, protecting the homeostasis of the organ (brain) and eliminating excess and waste substances (e.g., blood).

The development of this device takes into consideration the main concepts of neurophysiology and the phenomena of brain plasticity. The primary use, for which this device was designed, is for use in the operating room, during neurosurgical surgery for brain herniation or during other neurosurgical surgery where possible brain herniation is anticipated.

The device, therefore, can be used as a first-choice tool to intervene on the brain herniation, as a supportive operative tool in case other neurosurgical intervention has already started or, also, as a diagnostic tool for suspected brain herniation, while at the same time allowing a rapidity of intervention that would save valuable time for the neurosurgeon and the patient, otherwise, as far as I know, not possible.

For example, in the case of:
patient with severe head trauma, GCS (Glasgow Coma Scale) < 9 and pathologic brain CT scan (e.g., presence of hematomas and/or lacerated-concussive foci-edema)

Cerebral intracranial pressure > 20mmHg.

Therapeutic intervention is required to prevent and/or counteract cerebral herniation.

Whereas, the perfusion pressure, given by the difference between PAM (mean arterial pressure) and PIC (CPP = PAM-PIC), has physiological values if above 60mmHg.

Such a device has a woven mesh/mesh structure capable of compressing the brain tissue; compression and containment of swelling occurs due to the physical-mechanical properties inherent in the material from which the helmet is made. In addition, through sensors, specially placed in the interface between the device and the brain parenchyma, there is continuous monitoring of parameters: cerebral perfusion pressure, temperature, cerebral blood flow, etc.

It is, in my opinion, necessary that the helmet as a whole be able to cover the entire surface of the skull, once exposed, after removing the skullcap. This is because, in light of what has been enunciated above, brain hernias can occur at any level of the CNS, and therefore the device must be able to map and intervene at any anatomical point of the human brain, thus surpassing in this world the surgical techniques known so far, offering the possibility of being able to circumvent a fundamental obstacle in neurosurgery: the difficulty of surgically reaching a given area of the brain.

The helmet, precisely because it is in close contact with the brain parenchyma, must be made of biocompatible polymers, ceramics and hydrogels, (specifically, it must be compatible with brain tissue), by means of a 3D printer and equipped with certain essential characteristics: it must be elastic and compressible and at the same time capable of transferring signals (electrical and chemical). The choice of the biocompatible material must consider the fact that changes in the size of the encephalon (different from individual to individual and depending on the extent of the pathological event) may occur during surgery, which is why the material of fabrication CANNOT be a rigid material with little ductility. In addition to these preliminary characteristics, the helmet must function as an anatomical scanning and brain activity device to allow the neurosurgeon a complete acquisition of biochemical and anatomical information of the brain (like a kind of fMRI).

The application of this new device in surgery involves the removal of the skullcap, with exposure of the brain. The primary goal is precisely to reduce the invasiveness of the procedure and no longer resort to surgery as a last chance to save the patient, but as a tool of choice and first therapeutic choice in case of brain herniation and instrumental diagnosis in case of suspected brain herniation.

The choice to use biocompatible polymers is due to the fact that these materials, natural and/or synthetic, can work closely with living tissue, being also able to replace a part of organic tissue. Moreover, through special tests it is ensured, for example, that these materials are not toxic to the body.

3D printing of biocompatible materials offers better possibilities in terms of complexity and customization. All products made with biopolymers and 3D printer can be sterilized (the method of sterilization varies depending on the choice of material).

The structure of the biocompatible polymer, in this case, represents the skeleton of the device = mesh/braided mesh, (porous medium).

Sensors are incorporated into the helmet in contact with the brain parenchyma, sensitive to changes in blood composition and changes in pressure, temperature and solutes (of brain metabolism), etc. The operation of the sensors is very similar to that of the chemoreceptors and, like the helmet, they must also be totally biocompatible.

Integration with biosensors can bring many advantages, for example, it can enable automated monitoring of a wide range of analytes and biomarkers, later making the device also suitable for personalized study of disease or drug testing in diseases of the nervous system.

The sensors also are connected to a wireless transmitter, and the detected signals are read via an electronic board. Once the information is acquired, through an integration process, it is sent to an external monitor (screen) placed in front of the neurosurgeon.

Intraoperative imaging devices: magnetic resonance imaging (MRI), computed tomography (CT), fluoroscopy and ultrasound (US), are already widely used to provide better and more accurate navigation systems, which is critical when dealing with soft tissue, such utility, especially in neurosurgery, in which even the smallest opening of the skull (commonly referred to as a "minimally invasive procedure" or as "keyhole neurosurgery") results in intraoperative brain deformation, mainly due to cerebrospinal fluid drainage, becomes even more important. The use of wireless brain sensors, composed of biocompatible metals, e.g., magnesium, titanium, and zinc, which act as conductive elements, with co-glycolic acid polylactic biopolymers, allow constant monitoring of the brain's electrical activity (in the form of "brain waves" reflecting electrical transmission within the brain) and to detect pressure, temperature, and pH within the brain.

The wireless technology of these sensors can ensure continuous signal reception and data transmission from the brain to external analysis devices. The moment the sensors detect a change in parameters (even a minor one), thanks to the NICE (near-infrared coating) with which they are equipped, they light up indicating to the neurosurgeon where intervention is needed.

The use of these brain sensors must be incorporated with wireless microelectrodes (MEAs) that placed on the side of the brain parenchyma are able to penetrate it. Obviously, the substrate of the microelectrode must be flexible so as to un cause trauma, inflammation, etc. to the brain parenchyma.
One could use polylactic-co-glycolic acid as a biodegradable polymer, which can move like a "second skin" over the brain tissue, without causing trauma, in response to changes in the pressure of the fluid surrounding the organ.

Using a neural network interface with a diameter of about 20 micrometers, it is possible to record the impulses of a single neuron and observe the action potentials of the brain's surface, with wireless data transmission, so that it is possible to simultaneously detect information about the electrical state (like a kind of EEG) of nerve cells and about changes in the biochemical parameters, pressure, temperature, composition, etc. of the organ in question.

Taking into account the anatomical delicacy of the organ on which this device will have to go to work, it should be pointed out that the entire operation of the device, and thus also that of the chip that makes up the sensors, should be as similar as possible to the physiological functioning of the human brain, this is to allow the maintenance of the vascular system and not to cause further trauma (in addition to the pathological event already in place) once the device is applied.

The chip has electronic components (known as field-effect transistors) that, by detecting the chemical of interest, produce an electrical signal that can be detected and analyzed outside the body.

The sensors must respond only to the specific chemicals of interest and ignore the crosstalk of other biomarkers, in other words, the sensors must be able to detect changes in brain fluids while the electronics in the chips must be protected from these same fluids, and this would seem to be possible by proceeding with an impermeable encapsulation of the chip, with a thin film of silicon dioxide, forged at temperatures above almost 2000 degrees Fahrenheit.

The materials from which all the components of the helmet will be made must be biocompatible, elastic, heat and impact resistant, and with high conduction capacity (for electrical and chemical signals), this is to obviate the problem of incompatibility between these structures and the mechanical properties of the brain. Elasticity, on the other hand, is essential to avoid exerting excessive pressure on the surface of the brain that could cause inflammation and nerve destruction.

E.g., sensors made on a 3D microelectrode array with a flexible substrate would be easy to fabricate, perfectly compatible with tissue, and would not require invasive anchoring techniques.

At this point that the neurosurgeon, during surgery, has a complete reconstruction of the patient's brain structure, obtained by brain scanning (operated by the helmet itself) and to which the physiological parameters detected by the sensors are added. So, all information is available in real time and visible with improved image resolution.

A better image resolution of a relatively small anatomical space, such as the brain, integrated with biochemical/physiological information, allows the surgeon to reduce the margin of error.
The configuration of the sensors must allow an instant-by-instant analysis of what is happening inside the brain, even the smallest variation must be detected in real time; this is in order to better understand what needs to be done for successful surgery.

In addition to what has already been mentioned, the helmet must be equipped with an illumination system, such as a kind of "illuminated road" (fluorescence), which serves to signal, thanks to the work done by the sensors, the precise point where there is edema and where it is necessary to act, releasing pharmacological substances to counteract the pathological phenomenon. In this sense, the sensors function as true navigators: they analyze the condition of the organ and anatomically indicate where action is needed.

The interlaced mesh/network structure is articulated in horizontal and vertical "|_" lines, and this allows for a subdivision of the brain structure. Within these lines (= tubular structures) pharmacological substances must travel to their point of release.

In view of the drug treatment currently available to counter edema formation, I hypothesized that the substance released along the vertical "|" stretch could be mannitol, in non-continuous solution. Whereas, in the horizontal tract intersecting the vertical "_" tract would be corticosteroid release.

The possible choice of using mannitol and corticosteroids is due to their pharmacokinetic characteristics, which can reduce edema and counteract inflammation.

The lines (horizontal and vertical) that make up the woven mesh/mesh structure of the surgical device are tubular in shape and function as selective ion channels, equipped with a selectivity filter. Each of these channels (horizontal and vertical) has an inlet and an outlet found on the outside (of the skull) and inside (of the skull), respectively.

Each channel, in addition to the two ends (inlet and outlet) also has a kind of port-a-cath, both at the inlet and outlet, thus allowing the two pharmacological substances to enter and exit.

The two substances must enter and exit separately from each other, and it is only at the point of their release, calculating their timing well, that they must act synergistically.

1. the side that represents the inlet port (of each individual horizontal and vertical channel) is equipped with a kind of outflow (equipped with perforate, drip chamber, flow regulator, connector, circular tube, etc.) into which substances are injected, controlled manually by the neurosurgeon.

It should be pointed out that each inlet port has two different inlets for different substances.

2. the side that represents the exit port (of each individual horizontal and vertical channel), in contact with the brain parenchyma, has two "exits" that allow direct release of substances onto the brain tissue. Substances could also be released into the brain parenchyma encapsulated in biocompatible and biodegradable carriers.

This second option could be considered if, for example, in experimentation, "direct" drug release proves to be an unsuitable procedure. However, the operation of the channels (remember they are the lines that make up the lattice) would be the same,

with the difference that the drugs, instead of being injected and released directly, would first have to be incorporated into these bio transporters and then, thus structured, injected and released.

The helmet is surrounded by an outflow system (a roughly tubular-shaped structure that perimeters the helmet), equipped with suction and pressure pumps that allow the removal (literally the "throwing out" of the brain) of anything that is in excess and thus aggravating the patient's pathological picture.
On the outside of these small pumps are waste material collection bags.

The arrangement of these pumps is, in my opinion, as follows: one frontal, one posterior, and two laterals. In view of the anatomy of the brain you will have:

- one pump located at the frontal pole
- one pump located at the occipital pole
- two pumps located at the temporal lobes

To conclude, the helmet in addition to all the features previously listed and with all the necessary appendages: sensors, channels, outflow system, etc. that allow containment/compression of the brain structure, must also function as a kind of topographical map capable of detecting, instantaneously, what the brain needs to limit its damage.

All this is made possible, in my view, by finely tuned and integrated work of structures operating in series and in parallel. The advantage in using this surgical device lies first of all in the control it gives the neurosurgeon, in the operating room, instant by instant, of all possible variables and to intervene promptly, with less invasiveness and therefore less risk. Galena device lends itself, in my humble opinion, to be used for both ordinary and emergency procedures performed. In cases of cancer, ischemic stroke, diffuse edema, etc.

Taking also into account all the potentialities of the said device, in my opinion, its future use in the study of consciousness should not be excluded, thus contributing to a deepening and improvement of the neurophysiological knowledge of such a complex and still little-known subject. In addition, in view of the problems caused by increases in intracranial pressure due to long-standing space missions, I believe that Galena could be made available for space research and even military research, considering the severe traumatic events they face.

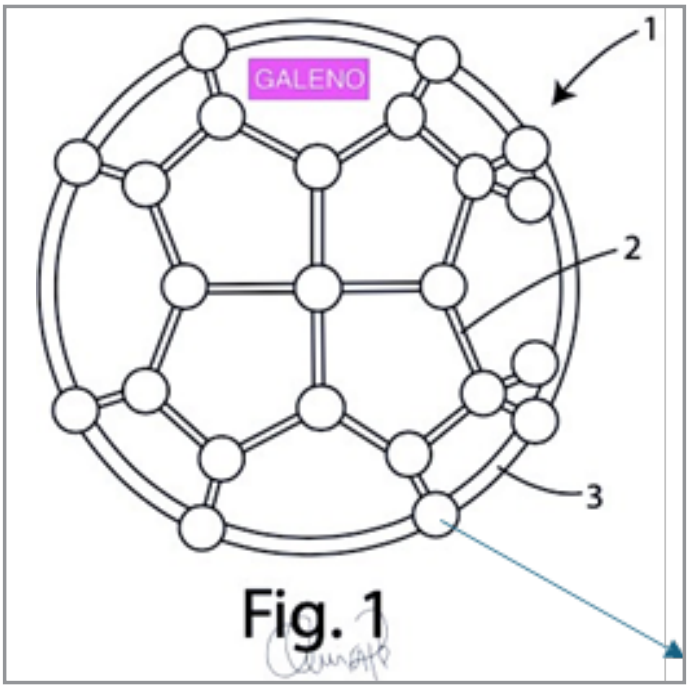

Fig. 1

point of intersection of canals (horizontal and vertical lines) where drugs are released directly into the brain (via nanoparticles)

Surgical device (Fig. 1) for cerebral herniation applied to the brain after decompressive craniectomy. The device (the helmet) has along the perimeter an outflow system comprising at least one drainage catheter and means of connection to an aspiration system, said outflow system being positioned along the perimeter of said structure and being adapted to convey waste liquids or blood outside.

Surgical device characterized in that said plurality of sensors comprises fluorescent biosensors, said sensors being coated with an ultra-bright and stable biocompatible fluorescent coating, for illuminating one or more areas of said surgical device (1), in particular corresponding to areas of the brain wherein said sensors determine the presence of an edema.

The sensors comprise at least one transducer of a neural interface, said transducer being adapted to register the impulses of a neuron.

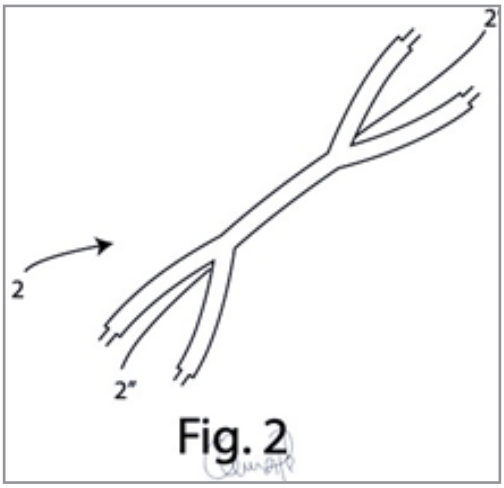

Fig. 2

Tubular canals including an inlet extremity (2') of one or more drugs and an outlet extremity (2") for the release of said one or more drugs into the cerebral tissue.

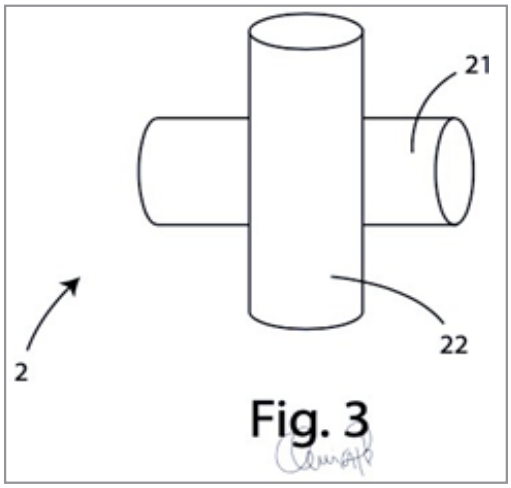

Fig. 3

Detail of canals

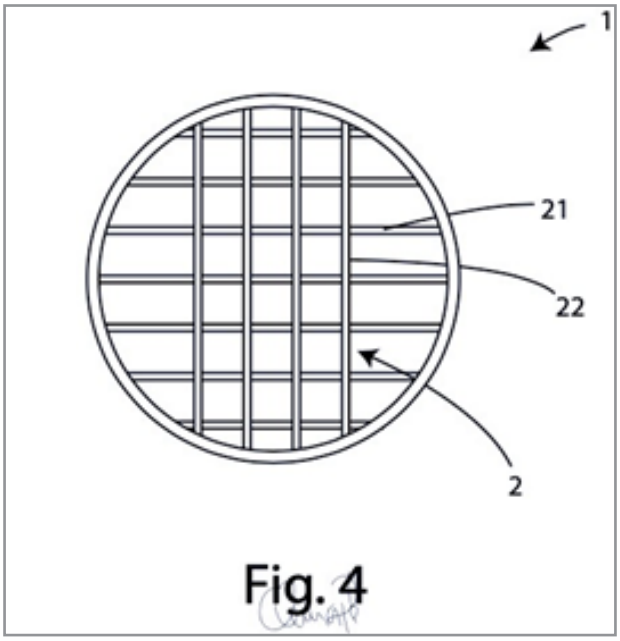

Fig. 4

A plurality of tubular canals (Fig. 4) divided into horizontal and vertical lines covering the entire surface of the helmet.

Surgical device characterized in that said structure comprises a first and second level of tubular administration canals, said first level comprising a first plurality of canals (21) parallel to each other and said second level comprising a second plurality of canals (22) parallel to each other and perpendicular to said first plurality of canals (21).