Digital Tools for Learning Anatomy to Enhance Student Performance in Undergraduate Lab Courses.

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Abstract

Several digital tools are now available in the market to help students study and understand the human anatomy. These supplemental resources are useful from both instructional and learning perspective. Students find them thought-provoking, hands-on experiences in a virtual environment. An attempt has been made to highlight the usefulness of one such digital tool in establishing a connection between what a student sees on the screen with the real world scenario. This paper discusses the concept and advantages of using a sophisticated tool, *BodyViz*, which allows stereoscopic visualization of 3D images of CT scans, in assessing feasibility of embolization of a tumor in a clinical situation.

Background

Each day 500 people are diagnosed with a primary brain tumor (around 66,000 new cases in 2012) , and about 4,200 children under the age of 20 before the end of the year will also be diagnosed with a benign brain tumor. Brain tumors are the second leading cause of cancer-related deaths in people under the age of 20.

A brain tumor can either be cancerous (malignant) or noncancerous (benign) depending on where the abnormal growth of tissue arises from. If it arises from the tissue surrounding the brain itself, it is benign and often has crisp borders that do not selfishly infect the surrounding lobes.
Symptoms of Brain Tumors: Headaches, pressure build-up, motor seizures, loss of sensory perception and motor control or loss of autonomic functions.

Brain tumors found within the confines of the blood-brain barrier (BBB) are benign, whereas the malignant tumors spread to other body regions disregarding the BBB, and are not likely to respond to induced embolization (Fig. 1).

Conversely, brain tumors may have their origin elsewhere, e.g. lung metastatic cancer in which secondary brain tumor cells resemble atypical lung cells rather than the usual brain cells. Similarly, teratoma - a germ cell tumor may manifest itself in the brain! Such brain tumors are not a good candidate for embolization, and are best excavated by surgery.

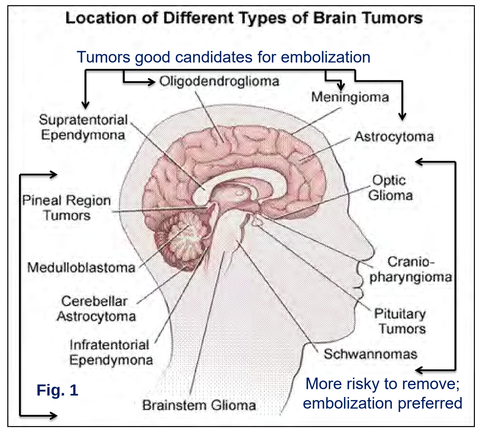

Fig. 1

Methodology

Advanced medical diagnostic tools like CT scan, MRI and PET scan are utilized to locate the tumor. The *BodyViz* software available in the Department of Biology & Biochemistry allows 3D visualization of anonymized patient data, and helps physician with strategic planning from a clinical perspective. In this study, data from a patient with brain tumor was analyzed with regard to the location, size, morphology, vasculature, and potential success of embolization in treating the pathology, if it was pursued. The selection of tissue types and the ability to cut virtually through the patient data volume provided much needed information to characterize the tumor under study. The blood supply to the tumor could be seen in 3D images using different coloring and clipping modes in the software. The zoom feature revealed details of the ramifications of the tumor by tilting the image in several different planes. In real world, Digital Subtraction Angiography (DSA), in which a contrast is created between the blood and the surrounding tissue making blood vessels stand out, is another favorite procedure which is adopted before carrying out the embolization.

Embolization: In this procedure, the blood vessel supplying the tumor is blocked by introducing embolic agent using microcatheter inserted through the dural branch preceding the internal carotid artery. Of the different types of embolic agents, e.g. polyvinyl alcohol (PVA) or ultramicro-sized pieces of metal coil are placed at appropriate location along the vascular route to block the nutrient and oxygen supply to prevent further growth, and to obstruct potential relapse after the tumor has been surgically removed. PVA is a nonuniform mixture of amorphous plastic particles commercially available in sizes ranging from 45 to 1180 µm. Generally, each vial contains a 200-µm size range (i.e., 300 to 500 µm) as a dry, coarse radiolucent powder that is reconstituted in contrast immediately prior to use. PVA particles cause a significant inflammatory response, which may add to the permanence of their occlusion. FDA-approved embolic agent, Bead Block, is made up of compressible and hydrophilic PVA hydrogel particles with theoretical decreased risk of clumping. This embolic agent is now frequently used as a drug-eluting bead for transcatheter chemoembolization procedures.

Among the Liquid Embolic Agents, Cyanoacrylates are tissue adhesive materials that polymerize rapidly once exposed to an ionic environment such as saline or blood, forming a cast of the vessel in which polymerization occurs. An inflammatory reaction often accompanies the polymerization process. Ethiodol (Savage Laboratories, Melville, NY) is mixed with the glue to render cyanoacrylate radiopaque.

Observations

It is much simpler to extract a benign tumor because of its clean-cut borders, but malignant tumors seep into the surrounding organs and their borders are much less evident. The case study selected for this investigation using the data files available in the *BodyViz* program, the images of the tumor viewed from different angles and at different magnifications suggest that it is a clear cut lobular tumor (Figures 2 and 3. However, a closer examination suggests that it has ramifications/extensions, and is perhaps not really a solid mass of encapsulated tissue (Fig. 4). This tumor falls right behind the eyes and could possibly be a infratentorial ependymoma due to its centralized intraventricular location within the brain, and trans-sagittal line arterial connection appearing in both the right and left hemisphere of the brains simultaneously (Figure 3), which would lead to symptoms of increased cranial pressure. It could be a malignant brain tumor because part of it is hollow, with the right lobe folding inward to its core and creating cave-like structures within itself (Figure 4). It appears very bumpy and fragmented on the smaller right lobe, which could mean it is seeping into a portion of the right hemisphere of the brain instead of keeping to itself like a benign tumor would (the left hemisphere depicts the lobular part of the tumor with a solid and clear cut structure (Figure 5). Without a biopsy and further imaging, it is unlikely that the tumor can be treated accordingly. Embolization of this tumor, if it is benign, would be beneficial because the surgical strategy would be simplified since it is not located in the deeper regions of the brain like the cerebellum or the brain stem (Figure 6 - 8). However, embolysis of this tumor, if it is malignant, would not be advantageous because it is built to deceive and spread, making it much harder to distinguish exactly which parts of the Internal Carotid Artery definitely supply it vague borders. Hypothetically, if this was a benign tumor and embolization was to performed, the micro-catheters would be most likely guided through the blood vessels indicated by the arrows in figures 4, 5 and 10. These deductions are based on the 3D visualization that the *BodyViz* software allows, and the inferences drawn from this study may be extrapolated to a real life situation where the neurosurgeon and radiologists must organize the modus operandi for diagnosis and treatment of this type of pathological condition.

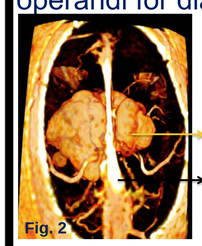

Fig. 2

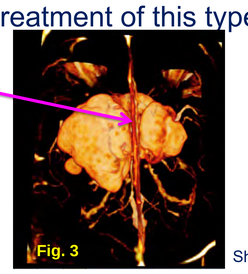

Fig. 3

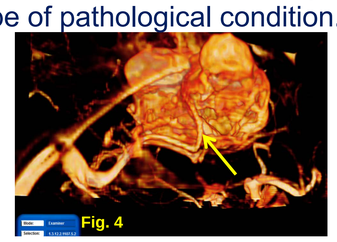

Fig. 4

Fig. 5

Showing exactness of tumor (fig. 3 - 5, 9 &10)

Microcatheter route (arrows fig. 4, 5 & 10)

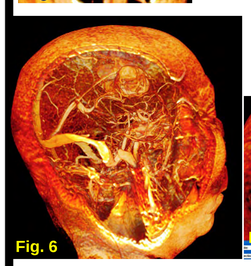

Fig. 6

Location of tumor in mediastenum far from brain stem (fig. 6 - 8)

Fig. 7

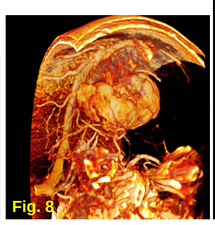

Fig. 8

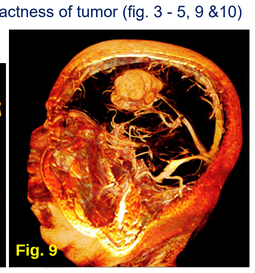

Fig. 9

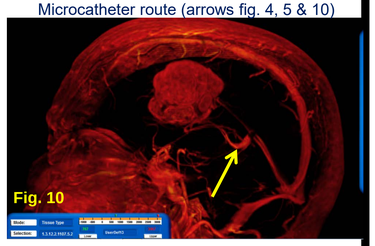

Fig. 10

Images of brain tumor visualized using 3D stereoscopic BodyViz software.

Conclusions

- The *BodyViz* program is an efficient tool that can be used in planning routes for the micro-catheters to inject the embolic agents into the arteries that supply the tumors thereby leading to their destruction.
- The *BodyViz* software assists in determining the type of tumor without having to do a biopsy.
- Versatility of the software not only assists in diagnosis but also helps plan invasive surgery after the tumor is embolized and remains need to be removed from the cranium by conventional surgery.

Acknowledgements

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