Project title: A mathematical modelling study on the effects of air expansion inside the brain on the intracranial pressure
Project code: OEH-119-03
Supervisor: Dr Ooi Ean Hin
Duration: 2 semesters

Background

Pneumocephalus is a phenomenon whereby air accumulates within the cranial cavity. This can occur due to various reasons, such as head trauma, erosion from extracranial infections and barotrauma, but of interest in the present study is the formation of pneumocephalus following brain surgery. Pneumocephalus post-brain surgery can occur due to the loss of cerebrospinal fluid (CSF) and the removal of abnormal brain tissue, where the empty space can be filled with air. Although pneumocephalus following brain surgery is generally not considered to be harmful, patients who have undergone brain surgery are often advised not to travel by air immediately post-surgery. This is to prevent the possibility of tension pneumocephalus associated with air travel, where the air cavity inside the skull expands in respond to the lower cabin pressure of the airplane [1]. The expansion of the air cavity compresses the brain, which can be harmful and may potentially cause mass effect and herniation.

Generally, the air entrapped within the cranial cavity is absorbed by the body within 4 to 6 weeks; however, the medical literature is at odds on the management of this problem. A survey conducted on consultant neurosurgeons in the UK found that the timescale in which patients are allowed to travel by air varies from less than 2 weeks to more than 8 weeks after surgery [2]. This varied timescale suggests that there is lack of evidence, standards and guidelines available in the literature [2], which presents a major problem to the management of pneumocephalus post-surgery.

Project Objectives:

The objective of the present study is to investigate the effects of changes in the ambient pressure and temperature on the increase in intracranial pressure. This will be accomplished through a mathematical modelling. Ideal gas law will be used to describe the relationship between the air pressure and temperature to the changes in the surrounding.

Scope of Work:

1. The mathematical model to describe the change in intracranial pressure will be adopted based on the intracranial pressure system developed by Marmarou et al. [3].
2. The model will be adapted to include the effects of air volume inside the brain.

Additional note:

1. This project requires strong analytical skills and good fundamentals in engineering mathematics.
2. Student must be well-versed in the programming language Matlab.
3. This project gives students the opportunity to blend their mathematical and engineering skills in the area of healthcare.
4. It is not necessary to have an in-depth knowledge of biology to take up this project.

5. This project is a collaboration between Sunway Medical Centre and Monash University Malaysia.

References

1. TJ Wilson, C Grady, E Braxton, E Weitzel, Air Travel with Known Pneumocephalus Following Outpatient Sinus Surgery. Aviation, Space and Environmental Medicine, 2014, 85:75-77.
2. A Amato-Watkins, VM Rao, P Leach, Air travel after intracranial surgery: a survey of advice given to patients by consultant neurosurgeons in the UK. British Journal of Neurosurgery, 2013, 27:9-11.
3. A Marmarou, K Shulman, RM Rosende, A nonlinear analysis of the cerebrospinal fluid system and intracranial pressure dynamics. Journal of Neurosurgery, 1978, 48:32-344.