

Magnetically Actuated Intra-gastric Balloon Device for Obesity Treatment

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PROJECT DESCRIPTION:

Motivation & Objectives

Obesity is a growing epidemic and has caused at least 2.8 million deaths per year according to World Health Organisation. One way to tackle obesity is by using intra-gastric balloons (IGB) to induce the feeling of satiety. Research literature has demonstrated that the combination of IGB and diet contributes to better weight loss than diet alone. Traditionally, the balloon needs to be administered through endoscopic procedures which increase the patient discomfort and risk of complications. To the best of our knowledge, there are only two commercially available IGB that can be swallowed directly without using endoscopy. However, in order to inflate their balloons, an extra tube is attached to the balloon which might be uncomfortable. Therefore, our current research aims to produce an IGB device that can be activated on demand by an external magnetic field. It can be swallowed just like any other medical pills and eliminated naturally from the body.

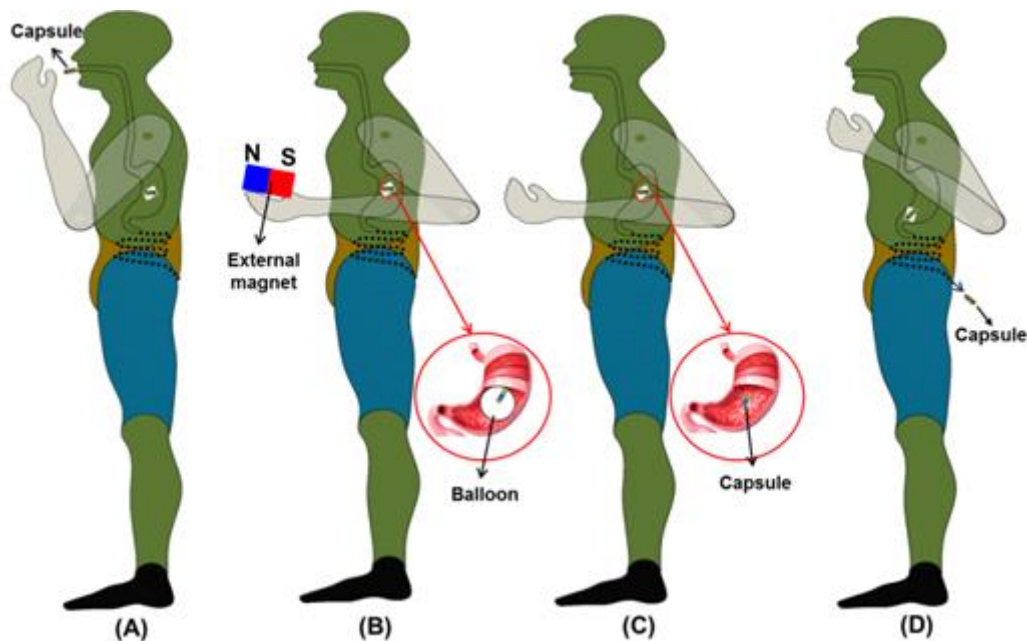


Figure 1: Four main procedures of using the magnetically actuated IGB device: (A) Swallow of the device; (B) Inflation of the balloon; (C) Deflation of the balloon; (D) Excretion of the device out of the patient's body.

Methodology

The IGB device is made up of two main components: the inner capsule and the outer balloon. The inner capsule consists of a magnet and a chamber which holds the acid. On the other hand, the base is stored in the balloon. The assembled component is then put inside a gelatine casing to make swallowing easy for the patients. The main material for the capsule and the balloon is polydimethylsiloxane (PDMS) due to its biocompatible, acid-resistant and elastic properties. Injection moulding and solvent casing are the fabrication processes for the capsule and balloon respectively. The acid and base used are citric acid and potassium bicarbonate respectively because of its relatively low toxicity and quick reaction that generates significant amount of carbon dioxide. Firstly, the patient swallows the device. Then, an external magnet is used to attract the internal magnet which opens the valve allowing the acid to flow into the balloon. The acid-base reaction will release carbon dioxide gas that inflates the balloon. After a month, the balloon will deflate and pass out of the body naturally. The deflation mechanism occurs by the carbon dioxide diffusion either through the balloon membrane slowly or the biodegradable plug that can be integrated onto the balloon.

Results

The prototype IGB devices have been fabricated and a few experiments have been carried out as shown in figure 2, 3 and 4. The IGB managed to fully inflate itself to the desired volume after 30 minutes. After a few hours, the IGB deflated upon the degradation of the deflation plug in the simulated gastric acid.



Figure 2: Inner capsule, outer balloon and the assembled IGB device (left to right).

Challenges and Future Research

The main challenges faced are as seen below:

1. To minimise the size of the IGB device. The desired total dimension is $\text{Ø}12 \text{ mm} \times 33 \text{ mm}$. As seen in figure 2, inner capsule with $\text{Ø}11 \text{ mm} \times 16 \text{ mm}$ has been developed.
2. To use a polymeric material with better rigidity for the inner capsule, e.g., polycarbonate.
3. To find a biocompatible, elastic, low carbon dioxide permeability material for the balloon. PDMS is unable to hold carbon dioxide gas for long periods of time. New materials are being investigated to satisfy all the requirements.

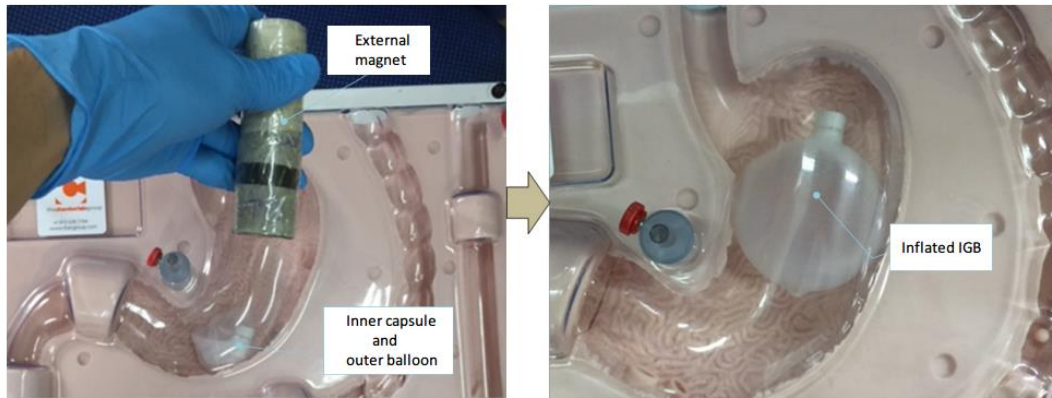


Figure 3: The inflation of IGB using an external magnet inside a virtual stomach.

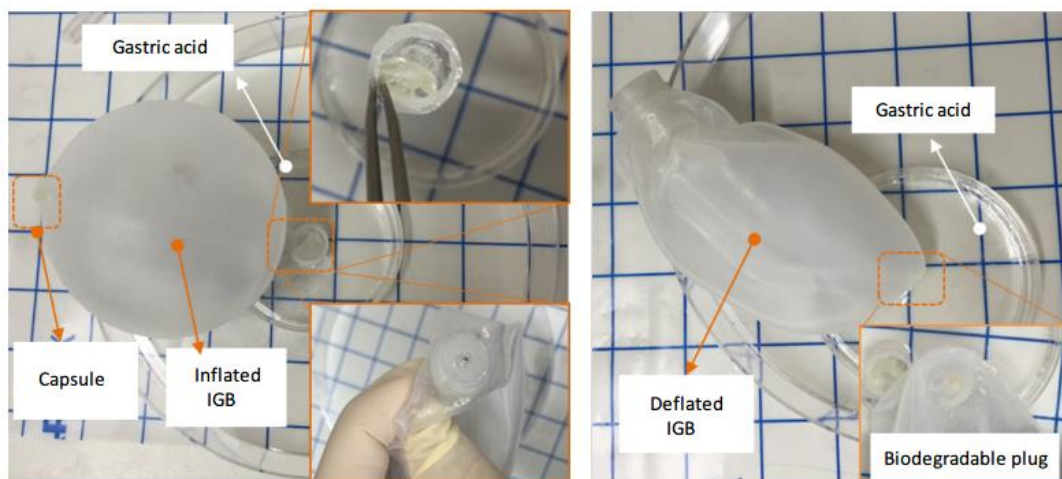


Figure 4: The proposed biodegradable deflation plug was dissolved in the simulated gastric acid causing deflation of IGB.

GRANT:

\$288,000.00, NTU Start-up Grant (SUG), 27 Nov 2014 – 26 Nov 2017

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PUBLICATIONS:

Refereed Patent:

[1] S. J. Phee, T. N. Do, T. E.T. Seah, K. Y. Ho, "Magnetically Actuated Ingestible Weight Management Capsule", No: 10201506629W, Singapore, Filed Date 21-Aug-2015.

Refereed Journal (Published/In Press):

[1] T. N. Do, T. E. T. Seah, K. H. Yu, S. J. Phee, "**Development and Testing of a Magnetically Actuated Capsule Endoscopy for Obesity Treatment**", *PLOS ONE*, 2016, Published.

Refereed Conference (Published/In Press): Nil.

[1] T. N. Do, P. P. Thien, K. H. Yu, S. J. Phee, "**A Magnetic Soft Endoscopic Capsule for Non-Surgical Overweight and Obese Treatments**", *IEEE/RSJ International Conference on Intelligent Robots and Systems, Korea*, 2016.