AUTOMATIC MONITORING OF OESOPHAGEAL PRESSURE DURING SWALLOWING

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Abstract
The main objective of this project is to design and implement a device which can sense the oesophageal pressure at different instants in a human body. This is performed with the utilization of pressure sensors. We present a simple and low-cost device for measuring the oesophageal pressure which also determines any kinds of abnormalities during the process of digestion. A throat cuff is used, which will consist the pressure sensors. When the patient swallows any kinds of food or even saliva, an oesophageal pressure is given out. This pressure is sensed by the sensors and the value of the pressure is displayed on the LCD. The display indicates if the pressure is normal or abnormal. This method can be used effectively for checking the oesophageal pressure during swallowing and also further helps in detecting various disease conditions at an earlier stage.

Introduction
The digestive system deals with the reception of food and with the preparation of it for assimilation by the body. The alimentary canal consists of the following parts; Mouth, Pharynx, Oesophagus, Stomach, Small and Large Intestine. In this project, we deal with the pressure measurement of the oesophagus while swallowing. The Oesophagus is a muscular tube 23 to 25 cm (9 to 10 inches) long, reaching from the pharynx above, to the cardiac orifice to the stomach. It lies behind the trachea to which it adapts and in front of the vertebral column. Passing through the thorax it pierces the diaphragm, to enter the abdomen where it communicates with the stomach. The oesophagus consists of four coats, an outer loose connective tissue layer, a muscular coat, composed of two layers of muscle fibers, longitudinal and circular, a sub mucous coat and an inner mucous membrane. When the food enters the pharynx, the soft palate rises to shut off the posterior nares, the glottis closes by contraction of its muscles and the constrictor muscles of the pharynx grasp the
food and pass it on to the oesophagus, at this moment breathing ceases or choking would occur. One cannot swallow and
breathe at the same time. This part of swallowing is a reflex action. The food passes through the oesophagus by
peristaltic action, the circular muscle fibers relax in front of the food and contract behind it, and the peristaltic waves
convey the bolus of food into the stomach [1, 2]. This project proposes a novel method in measuring the oesophageal
pressure during swallowing any kinds of substances, including saliva. It is purely a non-invasive technique in which a
throat cuff is used. This cuff consists of pressure sensors which are positioned at the oesophagus. This gives a pressure
value which denotes the pressure that is exerted by the oesophagus during the process of swallowing. A variation in
pressure is observed while in taking saliva, water and other food materials. This method is performed as a treatment in
gastroenterology department to check whether the patient has a normal or abnormal digestion process. Any kinds of
abnormalities or disease conditions can be easily diagnosed this way [4].

**Literature Review:** There were many ancient methods used to measure the pressure of the oesophagus while
swallowing. Some of them are as follows;

- **Oesophageal Balloon Method**

In this method, catheters and latex balloons are used in which these balloons are sealed over the catheters. The balloon
pressure is transmitted to transducers and the oesophageal pressure is measured (Pes) [5,6,8]. It is important to know that
the perimeter of the balloon should be similar to that of the oesophagus(4-4.8cm in human adults). Generally, 5-10cm
long latex balloons, with 0.1mm thick and perimeters varying between 3.2 and 4.8cm is considered ideal for detecting
the oesophageal pressure. When the pressure variation is too high, the frequency response can be improved by
increasing the diameter of the balloon catheter system.

The respiratory frequencies are seen higher in newborns than in adults[10,11]. Therefore, when the respiratory
frequencies are higher, the internal diameter of the catheter should also be high(1.4-1.7mm) but should also be as short
as possible[14,22]. Finally, the catheter should be made of spirally arranged holes covered by the balloon as catheter
manometer system and the oesophageal pressure will be incorrect. The optimal level of gas in the balloon should
approximately be 0.5mL of air. The range of volumes of working gas should be determined. For this, a three way
stopcock is connected to the catheter end and its left portion will be open to the atmosphere. A pressure transducer will
also be attached to the other port of the stopcock.
The balloon is made empty by submerging in water and the stopcock will be kept in such a way that the pressure transducer gets connected to the balloon catheter system [18][28].

- **Liquid-Filled Catheter Method**

The liquid catheter method is being used for the past many years especially in neonates and small animals. This method has got the advantages of high frequency response because of rapid pressure transmission through a non compressible fluid (it can be water or saline)[6]. It thus follows catheters narrower which is mounted by oesophageal balloon which can be used without the loss of fidelity of the measurement. The discomfort of the babies can be minimized by such small bore- tubes. There are some disadvantages in liquid catheter method that the absolute value of $P_{es}$ cannot be obtained because of hydrostatic factors[25,26]. Moreover its distal end must be provided with several holes to avoid mucus plugging of the catheter and the flushing of catheter should be done at the proper interval of time. A constant infusion of liquid at a slow rate from a syringe pump can be used , which also serves to keep the catheter as gas free bubbles that might over damp the recorded pressure[12,19]. This method has been performed by using occlusion test in healthy full term new borns. Measurements were made in all kinds of conditions like quite sleeping and wakefulness in all postures including supine, lateral, prone etc. the group average $P_{ao}$ was less than $P_{es}$ by only 1.6%. during the occlusion test the preterm neonates studied with water filled catheter system also had a finite region of oesophagus where $P_{es}$ was equal to $P_{ao}$ using an ideal balloon catheter method system a decrease in $P_{es}$ relative to $P_{ao}$ was observed upto 6%[26,23]. But when the same test was conducted when the new term neonates were in rapid eye movement sleep the agreement between $P_{es}$ and $P_{ao}$ wasn’t assured. The liquid-filled catheter method also has application in small animals. As predicted, both narrow and wide short catheters are reliable, and the correct catheter placement can be established using the dynamic occlusion test[6,7,27].

- The presently used devices in hospitals include a myometric instrument which gives out a graphical representation of the oesophageal pressure.[29,32]

- The latest monitoring of oesophageal pressure is done using pressure sensors.

**Materials Required**

Components required includes,
- Sensors
- Analog to Digital Converter
Description of Components

- Pressure sensor will check the oesophageal pressure
- ADC will convert the analog value to digital value
- Microcontroller compare the output from pressure sensor with the threshold and indicate if any abnormal conditions
- Display unit displays the instantaneous pressure

Methodology

A throat cuff is used, which will consist the pressure sensors. When the patient swallows any kinds of food or even saliva, an oesophageal pressure is given out. This pressure is sensed by the sensors and the value of the pressure is displayed on the LCD. The display indicates if the pressure is normal or abnormal, using which further diagnosis is performed by a doctor/physician. If the value is normal, there will not be any problems in the digestion process.

Block Diagram

`Pressure sensor` → `ADC` → `Microcontroller` → `LCD display`

Circuit Diagram
Conclusion

Several methods for measuring changes in oesophageal pressure can be safely employed in both human subjects of all ages and experimental animals. A thorough knowledge of the methodology involved is essential so that reliable measurements are obtained. This method can be used effectively for checking the oesophageal pressure during swallowing and also further helps in detecting various disease conditions at an earlier stage.

References

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