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REGULAR ARTICLE

A novel device for extracting chyme from gastric cavity ☆

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Abstract Negative pressure drainage (NPD) technology is required to extract chyme from the gastric cavity of the patient suffering from stomach disease in order to observe the mucosal condition of the gastric cavity clearly and to avoid being misdiagnosed in gastroscopy. However, there are problems, such as insufficient vacuum and easy clogging, in the current NPD devices. To deal with these problems, by applying the principle of hydraulic check valve, a novel device, convenient to extract chyme from gastric cavity, is discussed in this article, which will meet the clinical demand. The proposed new device has the advantages of enough vacuum degree, smooth drainage without backflow and blockage, and has a better application prospect as compared to existing devices.

Introduction

Gastroscopy is extremely popular in the diagnosis of lesions in the upper gastrointestinal (oesophagus, stomach and duodenum) region [1,2]. With the help of a slender, flexible drainage tube stretched into the stomach of the patient in gastroscopy, doctors can directly observe the anomalous changes of intestine, make judgement on lesions, measure the focal size or take a small piece of living tissue from the lesion site by the plier for pathological examination. Gastroscopy has a unique efficacy to judge the degree of chronic gastritis and intestinal metaplasia, to identify whether it is benign or malignant for the ulcer, to determine the causes of upper gastrointestinal haemorrhage and to detect the gastric cancer at an early stage [2,3].

☆ Within the knowledge of the authors, no evidence was found in the open technical literature of research work addressing studies of suction device for chyme based on hydraulic check valve. It is for this reason that few references to the previously published material are provided in this paper.

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Chyme is a kind of porridge-like semiliquid. Food, chewed by teeth, stirred by tongue and mixed with saliva, is swallowed down the stomach where it is milled into a state of being more broken due to the movement of gastric wall muscles and fully mixed with gastric juice, thereby resulting in the formation of chyme. In order to observe the mucosal surface and tissue inside the digestive tract and stomach of the patient clearly, and to avoid faulty diagnosis, the inspection area must be very clean, that is, no chyme and no survival of blood clot should exist. The provision that the patient is not allowed to eat after 8.00 pm the day before gastroscope inspection is mandatory, so as to let the stomach be in an empty state while the examination is performed. Gastric lavage should be done in the evening before inspection if the patient is suffering from pyloric obstruction and the stomach is to be cleaned thoroughly until flushed backflow liquid is clear. Negative pressure drainage (NPD) technology is needed to extract chyme from the stomach of the patients who have rather weak gastrointestinal functions and those who have chyme retention in the stomach, as it is difficult for them to discharge the residual chyme completely out of the stomach. In such cases, the chyme would influence doctor's observation, which would make an accurate diagnosis difficult.

Based on the principle of air suction at a controlled sub-atmospheric pressure, NPD or vacuum-assisted closure is a promising new technology applied in a variety of difficult-to-manage acute and chronic wounds [4,5]. There are two major kinds of artificial drainage methods widely used in clinics at present:

(1) Employing a disposable NPD apparatus with a compression spring. After inserting an indwelling drainage tube inside the stomach of the patient, certain negative pressure is created by compressing the spring in the apparatus, then NPD is realised. The apparatus with spring is flexible and portable and is a permanent appliance in first aid nursing and in surgical treatment. However, it was found in practice that its negative pressure was insufficient (the negative pressure is only 30 mmHg or so) and the drainage effect was unsatisfactory for the extraction of chyme from the stomach using this type of drainage apparatus.
(2) Connecting a rubber drainage tube for suction through a syringe. Pulling out a cylinder of chyme with the syringe and then squeezing it out of the syringe. The negative pressure is sufficient, but the operation is troublesome and there are less extractives in each cycle. The head of the syringe is often blocked with chyme in the stomach and the drainage process is impeded, because the aperture of the head in the syringe is rather small (the inner diameter is about 2 mm only). Physiological saline is required in this case to wash the drainage tube and the head with a new empty syringe, and to clean the stemming repeatedly to eliminate the flow resistance of chyme and continue the operation. Obviously, the operation is time consuming and laborious. The backflow of chyme will occur if the operator does not pay enough attention to the job, which will result in retrograde infection.

The aim of this study is to solve problems existing in the current NPD technology and try to develop a new device convenient to extract chyme from gastric cavity without blockage and backflow.

We already have the patent application for invention of this device in China [6].

What does the new device consist of?

The new device to extract chyme out of the gastric cavity, as shown in Fig. 1, is mainly composed of intake valve core (3), drain valve core (8), valve sleeves (2, 5), valve covers (4, 9), connecting tube to syringe (6) and drainpipe (10). The intake valve core (3) allowing chyme to flow only to the right side is installed inside the left valve sleeve (2), the drain valve core (8) allowing chyme to flow beneath is set inside the right valve sleeve (5). The connecting tube (6) and the drainpipe (10) are glued to the right valve sleeve (5).

There are radial hole (*a*) in the intake valve core (3) and centre hole (*b*) in the left valve cover (4). Radial hole (*k*) connected to the centre hole of the tube (6) and radial hole (*e*) connected to the centre hole of the drainpipe (10) are drilled into the right valve sleeve (5).

The functions of intake valve core (3) and drain valve core (8) are different. Intake valve core can prevent chyme flowing back into the patient's body. Drain valve core guarantees that chyme extracted from the body discharges into a liquid receiver.

Two springs, installed inside the grooves of the intake valve core (3) and drain valve core (8), respectively, ensure that two cores return correctly and the chyme flow is in one-way direction only. They do not come in contact with the chyme. In order to make the two cores work flexibly and reliably and to reduce energy losses of chyme flow, the stiffness of the springs is determined according to the rule that the spring force is somewhat larger than the friction resistance of the cores in motion and the inertia force. Generally, the spring stiffness in the intake valve core (3) is determined by a negative pressure between 75 and 112 mmHg in cavity *B*. The spring stiffness in the drain valve core (8) depends on the pressure in cavity *E* between 225 and 375 mmHg.

An intake pipe (1) is inserted into the centre hole of the left valve sleeve (2) from the left end. The nipple of syringe (7) is inserted at the top of the connecting tube (6). The diameter of the centre hole in the left end of the valve sleeve (2) is equal to the outer diameter of the intake pipe (1). The diameter of the centre hole on the tube (6) is the same as the outer diameter of the nipple on the syringe (7).

The valve sleeves (2, 5) and left valve cover (4) and the right valve sleeve (5) and right valve cover (9) are tightened with bolts.

All components of the device are manufactured with polyethylene or silicone rubber except the two springs and the bolts that are made of stainless steel. By replacing the intake tube (1), this device could be reused after disinfection treatment.

How does the new device work?

The new device functions as a tool for suction and discharge of chyme from the stomach of the patient, so that gastroscope observation could be done clearly. The operating principle and the usage of the device are described as follows.

As shown in Fig. 2, hold the left valve sleeve (2), insert the nipple of syringe into the upper end of the centre hole of the connecting tube. Placing a receiver (11) (the receiver could be