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REGULAR ARTICLE

A novel device for extracting chyme from gastric cavity ☆

Ai-Juan Shen [a], Hai-Lin Zhu [b,*], Jian-Hua Duan [c], Min Zou [b], Ying Jiang [a]

[a] Section of Tumor Radiotherapy, Shaoxing Second Hospital, Shaoxing, Zhejiang, China
[b] School of Mechanical Engineering, Changzhou University, Changzhou, Jiangsu, China
[c] Section of Digesting Internal Medicine, Shaoxing Second Hospital, Shaoxing, Zhejiang, China

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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.

* Corresponding author. Address: School of Mechanical Engineering, Changzhou University, Changzhou, Jiangsu 213016, China. Tel.: +86 0 135 84349948, +86 0 519 83284985; fax: +86 0 519 83290205.
E-mail addresses: fei678yao@sina.cn, zyx93@163.com (H.-L. Zhu).

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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

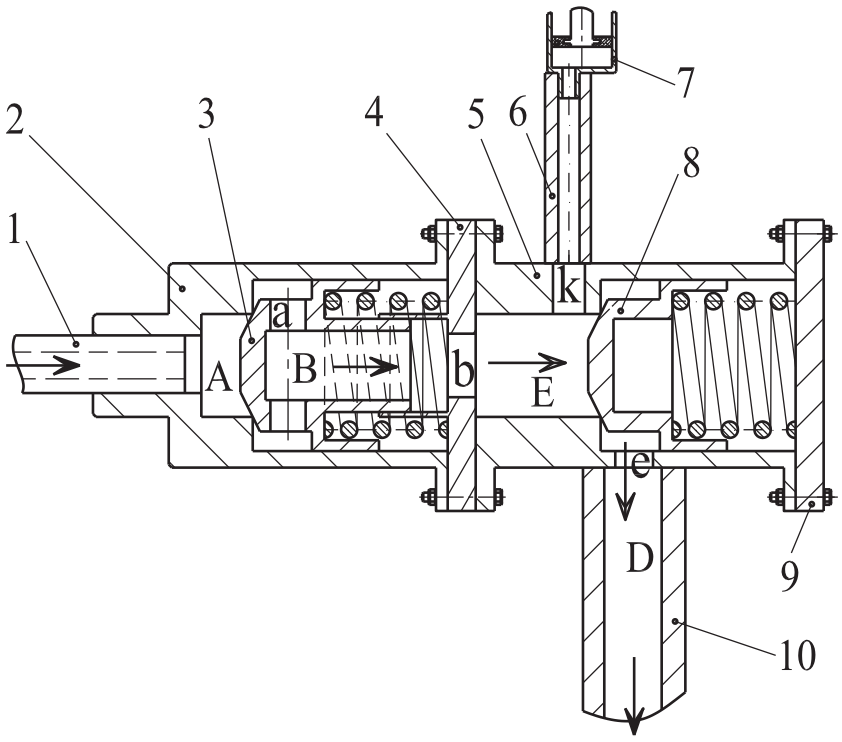

Figure 1 New extracting device for chyme. 1. intake pipe, 2. left valve sleeve, 3. intake valve core, 4. left valve cover, 5. right valve sleeve, 6. connecting tube, 7. syringe, 8. drain valve core, 9. right valve cover, 10. drainpipe.

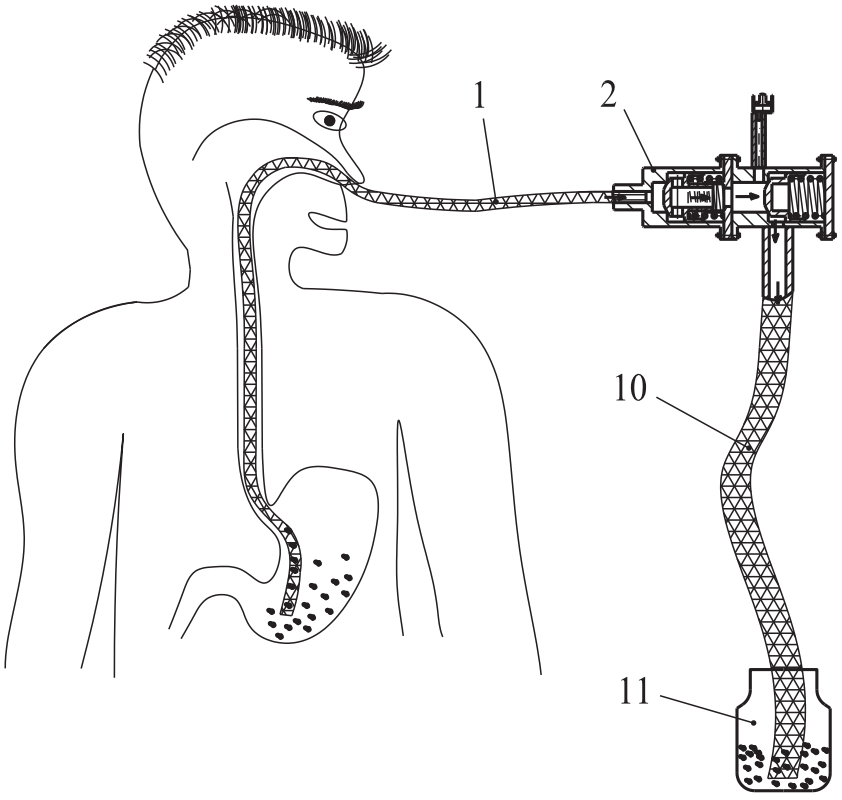

Figure 2 Application of the device for chyme suction from stomach. 1. intake pipe, 2. left valve sleeve, 10. drainpipe, 11. liquid receiver.

a glass bottle or a plastic bag) for collection of effluent underneath the drainpipe (10), insert the suction pipe (1), which is exerted through the nostril from the stomach into the left-side hole of the left valve sleeve (2).

As shown in Fig. 1, when the piston in the syringe (7) is pulled upwards, partial vacuum in cavities *B* and *E* is created due to the expanding volume of closed space below the piston, which helps move the intake valve core (3) to the right by overcoming the friction and the spring force; the two cavities *A* and *B* are then connected. When the drain valve core (8) is closed due to the negative pressure and the spring force, cavities *E* and *D* are separated from each other. Chyme is drawn from the patient's stomach into cavity *E* through cavity *A*, the radial hole (*a*) in the intake valve core (3), cavity *B* and the centre hole (*b*) in the left valve cover (4). Closed space is then filled with chyme. This is the suction process for chyme.

As shown in Fig. 1, when the piston in the syringe (7) is pushed downwards, pressures in cavities *B* and *E* increase due to the decreasing volume of closed space below the piston, which helps move the intake valve core (3) to the left due to the pressure and close the core; then cavity *A* is separated from cavity *B*. Overcoming the friction and the spring force, the drain valve core (8) moves to the right and two cavities *E* and *D* are then connected. Chyme trapped in cavities *B* and *E* is squeezed out under pressure to the drainpipe (10) through the radial hole (*e*) in the right valve sleeve (5), then to the liquid receiver. This is the discharge process of chyme. If the piston is moved up and down continually, the process repeats.

In case the negative pressure disappears suddenly, such as the piston is pulled out of the cylinder of the syringe (7), or the drainpipe (10) is withdrawn from the liquid receiver or the receiver is knocked over or crushed, intake valve core (3) will move to the left at once and seal the valve port under the spring force, and cavities *A* and *B* are blocked. Chyme cannot flow from cavity *B* to cavity *A* which prevents the chyme from flowing backwards, eliminating the hidden danger of retrograde infection, and thereby enhancing the safety of this device in practice. The extracting process for chyme could continue after the fault is debugged.

The through-hole diameters in the intake valve core (3), drain valve core (8), left valve cover (4) and right valve sleeve (5) are designed such that they are larger than the diameters of centre holes in the current drainage tube and therefore chyme can flow smoothly without blockage, thereby improving the efficiency in extraction and discharge of chyme.

Why is the new device better?

The new device proposed in this article has the following advantages compared to the devices currently used in clinics for drainage of chyme in stomach:

(1) If the negative pressure is unstable or dies out in the pumping process of chyme, the intake valve core will shut quickly under the spring force, which can prevent retrograde infection resulting from the backflow of chyme.
(2) The magnitude of the negative pressure can be adjusted. Effectively, the technique converts a passive into a controlled way in vacuum effect. The diameter of each through-hole in the flow path is larger, ensuring that chyme flows smoothly without stoppage, continuous drainage is realised and the drainage efficiency can be then increased in a controlled way.
(3) The operation is simple and convenient, which is easy to master by the medical personnel or family members of the patient, thereby alleviating the labour intensities of operators.
(4) The pain that the patients suffer from a long time of drainage operation is relieved, which embodies the hommization design.
(5) This device can be installed in series to the existing drainage system and it can also be used for body fluid suction in surgery, etc.

Evaluation of hypotheses

The new device is confirmed by the following studies:

(1) We suggest to evaluate and compare the efficiency of the new device to that of current devices. This is to evaluate and confirm that the suggested new device provides enhanced efficiency in auxiliary treatment before gastroscopy.
(2) It is proposed to confirm, by the principle of check valve in hydraulic system, the operation principle of vacuum pump, etc. to ensure the possible interaction between the chyme and the new device.
(3) We propose to confirm the formation of the new extracting system by any of the established techniques such as vacuum pump, hydraulic check valve, negative pressure method, etc. Steps must be taken to prove the efficacy of the new extracting system, as it is superior in the efficiency without backflow and blockage as compared to current systems. This is to confirm the formation of enough vacuum with optimum and suitable designing.
(4) We propose to study the quality, size and shape of chyme extracted using the new device. This study is done to ensure the efficacy of the new device with that of current devices.

Conclusions

It is unavoidable for each of us to get sick in our lifetime because we eat miscellaneous grain crops affected more or less by various contamination. With the rapid increase in population, more and more people will suffer from stomach diseases due to unclean food and medical personnel will be even busier. There is an urgent need to resolve the deficiency existing in the current NPD system, so as to improve the efficiency of auxiliary treatment. However, little research has been done in this field, and no new advanced product is found up to now.

With performance advantages such as preventing plugging and flowing smoothly, the new device introduced in this article appears to be particularly useful for extracting chyme and could be used as an advanced product as against the traditional drainage apparatus as it becomes more widely available.

Comments

The device presented in the article is innovative; no other references have been mentioned before on drainage device for the

extraction of chyme from stomach with advantages such as preventing plugging and flowing smoothly.

Conflict of interest

The authors state that they do not have any conflict of interest.

Overview Box

First Question: What do we already know about the subject?
Gastroscopy is extremely popular in the diagnosis of lesions in the upper gastrointestinal region. NPD technology is required to extract chyme from the stomach of the patient in order to observe the mucosal condition of stomach clearly and to avoid being misdiagnosed in gastroscopy. However, there are problems, such as insufficient vacuum and easy chances of blockage, existing in the current negative pressure drainage devices with spring or applying syringe.

Second Question: What does your proposed theory add to the current knowledge available, and what benefits does it have?
The new device, adopting the principle of hydraulic check valve, provides a viable option to overcome the problem associated with vacuum and blocking. With the help of the new device discussed in this article, doctors can observe the mucosal surface and tissue inside the digestive tract and stomach of the patient clearly and avoid faulty diagnosis.

Third question: Among numerous available studies, what special further study is proposed for testing the idea?
We suggest evaluating the new device among different patients for its efficiency. Further studies are needed to attain a better design for this new device. We suggest a detailed examination on the quality, size and shape of chyme to determine whether the new device shows a promising and bright future.

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