ABSTRACT

With the development of medical technology, intellectualization has become a tendency of future development. As a fundamental method of medical treatment, infusion has various type of devices. The design in this research combines the feature of medicine heating, medical monitoring and mobility, and the problems in infusion processes are solved, which can build a better relationship between patients and doctors.

INTRODUCTION

As a significant treatment method in clinical medicine, intravenous infusion is widely used in hospitals. Statistics suggest that hospital infusion rate in China every year can be as high as 98%, and several serious problems need to be solved in these infusion works.

There are lots of inconvenience during intravenous infusion from the view of patients, doctors and nurses. If a patient goes to the toilet during the infusion, another person is needed to accompany because of the size of infusion holder, which gains the mental stress of the patient. On the other hand, drugs of low temperature can also cause discomfort even complication to patients. From the perspective of doctors and nurses, the physiological status of patients can become a burden. Therefore, an infusion Device that can solve the above problems is necessary.

Infusion holder is a significant tool for medical treatments, however, the infusion holders that are used by most hospitals have simple structures and functions. Although there are several different types of infusion structures such as console infusion holders, orbit infusion holders, they still cannot meet the requirement of patients and medical workers.

As a main equipment of intravenous infusion, an optimize-designed infusion holder can be a best carrier to solve the above problems. By combining drug heating, real-time monitoring and easy motivation to infusion holder, the comfort of patients can be promoted effectively. In addition, the real-time monitoring of patients by doctors and nurses becomes convenient.

By optimized design of intelligent medical infusion devices, the infusion environment and experience of patients can be improved to a large degree, and patients can be more comfortable during infusion. Meanwhile, the work pressure of doctors and nurses can be reduced, and the work efficiency can be promoted. Hence, a harmonious relationship between patients and doctors can be built.

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CURRENT PROGRESS

At present, there are several types of proposed intelligent medical infusion devices. Some of the devices use thermos bottles or hot-water bags to make the drugs warmer to gain comfort of patients. However, air bubbles can be easily generated by this method, and the effect of some drugs with unstable features may be reduced, even adverse reactions can be gained.

To keep track of the infusion process, a monitoring system is necessary in the intelligent infusion devices. Most of the current products or inventions adopt wired or wireless monitors, and some buttons are prepared for patients to communicate with doctors and nurses.

Some of the mobile infusion devices that are currently in use are made of metal, and some wheels are attached under the infusion holder. However, these devices are too heavy for some weak patients and are hardly to accommodate the different environment in the hospital.

RESEARCH METHOD

Interview

By interview, the psychology and behavior of interviewee can be understood. In this research, patients, relatives of patients, doctors and nurses are interviewed to find out and solve problems relative to infusion devices.

Medical Literature Analysis

The bibliography relating to this research is analyzed to comprehend different methods of heating infusion tubes, monitoring and mobility. The fundamental principles of the heating devices, videos and wheels are researched to build a foundation base for solving the problems of this project.

Behavior Study

After designing this intelligent medical infusion device, the behavior of patients is simulated to optimize the product. In the experiment of this project, some problems are discovered and the solution to these problems are obtained by analysis the causes and effects of them.

WEARABLE AUTO-HEAT SKIN TEMPERATURE CONTROLLING DEVICE

Investigation Situation and Problem Analysis

Intravenous infusion is an important medical method. However, because of the low temperature of environment, the own situation of patients, and feature of some drugs, heating is necessary during infusion to decrease the stimulation to patients. Traditional heating method is heating infusion tubes by thermos bottles or hot-water bags.

By interview and investigation in the First Affiliated Hospital of Harbin Medical University and the Hospital of Harbin Institute of Technology, two heating methods are adopted by relatives of patients. One of them is winding the infusion tubes on thermos bottles or hot-water bags, and the other is putting hot-water bags on skin where the needle passes with a water temperature of 60-70°C.
Because there is a large temperature difference between inside and outside of infusion tube, a quantity of small air bubbles can be generated in the drug liquid. By continuous heating, air embolism may be caused to threat to patients’ lives. Some medicines in clinical application, such as biological agent and penicillin, are instable with a low efficiency while they are heated.

After interviewing several doctors and nurses, the feedback is that hot compress is a kind of heating method. Heating skin directly can increase the temperature of liquid that entering human body, decrease the cold stimulation to vessel wall, and gain comfort to patients. Furthermore, heating can also reduce the excitability of pain nerve and relieve pain. In addition, phlebitis can also be avoided by hot compress. Therefore, a new heating method that heating skin along blood vessels can lead to a perfect result and prevent disadvantages of infusion especially some drugs with high stimulus such as azithromycin and mannitol.

The device designed in this research can decline the discomfort and pain of patients during infusion. By a wearable auto-heat skin temperature controlling device, the temperature difference between medicine and the patient’s body can be decreased, and a more comfortable feeling can be achieved.

**Working Principle**

The wearable auto-heat skin temperature controlling device is made of a flexible heating cloth, with a Velcro sewed on it, which is like an electric blanket. The device is easy to put on and take off, as shown in Fig. 1.

![Flexible Heating Cloth & Temperature Sensor](image)

Figure 1. The Wearable Auto-heat Skin Temperature Controlling Device.

During usage, a temperature sensor is used to achieve heating temperature and feedbacks the data to controller, which starts and pauses the heating module, as a closed loop.

Users can also adjust the temperature as expected by a knob. The block diagram of heating control function is shown in Fig. 2.
Advantages

The wearable auto-heat skin temperature controlling device is made of soft cloth, and it can be folded to decrease its volume and is easy to wear and take off.

The convenience of operating and low costs makes this device able to be commonly applied in hospitals.

This device has a low power consumption, a fast heating speed and high degree of safety. While the temperature has raised to the pre-set value, the heating controller will power off automatically, which can avoid the harm to patients by elevated temperature.

The lifecycle of this device is long enough to make it with high economic efficiency.

VIDEO MONITORING SYSTEM

Investigation Situation and Problem Analysis

Medical workers or relations of patients need to keep an eye on the speed of infusion, liquid quantity, and the feeling of patients, such as pains and heart rate, in order to avoid hidden danger that air enters blood vessel and causes blood return or aeroembolism. If the infusion tube is not pulled out immediately by medical workers while infusion is finished, negative effects can be caused.

As shown in investigations, the monitoring measures commonly used in hospitals at present are emergency buttons and safety monitors. While there are some emergency situations such as allergies or bleeding, the patients or their relatives can press the emergency button. However, if there is no other people than the patients themselves, it is very dangerous while some emergency situations happen. On the other hand, the safety monitors usually cannot cover all the corners in the sickrooms, so that the medical workers may omit some situations that may be actually urgent. Therefore, emergency rescue may be delayed because of the disadvantages of these monitoring measures.

The infusion device designed in this research builds a real-time video monitoring system to resolve the problems above.

Working Principle

The wireless camera is integrated on the top of infusion holder, and the video is transferred to the nurse station by indoor Wi-Fi in real time. A monitoring application
software in monitoring end can receive the videos and the medical workers can monitor the situation in sickrooms conveniently. The block diagram of this module is shown in Fig. 3.

![Block Diagram of Video Monitoring System](image)

**Figure 3. The Block Diagram of Video Monitoring System.**

**Advantages**

Doctors and nurses can react to emergencies immediately by monitoring wards in real time with this video monitoring system, and both the psychology burden of patients and work load of medical workers can be reduced.

The cost of this video monitoring system is low, and it is easy to use. Besides, there is no restrict in type of device and position.

**OMNIDIRECTIONAL MOVEABLE SUPPORTING DEVICE**

**Investigation Situation and Problem Analysis**

Traditional vertical infusion holders are made of metal, which have a large volume and are difficult to move by medical workers. Moreover, the infusion holders without an efficient fixing method can be pulled down easily, which may hurt patients and medical workers.

At present, most kind of infusion holders used by hospitals cannot be moved, by which patients are always confined in a narrow space around the infusion holders without any activities. Some patients who suffered from gastrointestinal, hepatobiliary, pancreatic operations or appendectomy should restrict dietary and have continuous intravenous infusion. The stationary infusion holders make it difficult for patients to move around, which is not beneficial to the recovery of gastrointestinal function. Therefore, a moveable infusion holder is significant to the movement and promote the recovery of patients.

**Working Principles**

A universal wheel (Mecanum Wheel) is adopted in this device and makes it convenient to move in any direction, as shown in Fig. 4.
To fix the infusion holder, two elastic buckles are installed. The upper elastic buckle can be used while the patient goes to the toilet or other privacy environment, and the lower elastic buckle is used in other situation and can match the sticks on the wall of hospital. The elastic buckle is shown in Fig. 5.

**Advantages**

The requirement of indoor activity of patients who have continuous intravenous infusion is satisfied by this device, which benefits to the recovery of patients to a large degree. Besides, this device has high stability while it is moving, which guarantees the safety of patients.

This infusion holder is easy to produce and transform, saving the costs of hospital. The elastic buckles make it convenient to fix the infusion holder. This product can also protect personal privacy by a humanized design.

**CONCLUSION**

Intravenous infusion is a commonly used medical measure and infusion holders are the usual instruments for this process. However, traditional infusion holders have some limits in the aspects of heating drugs, monitoring and mobility. An intelligent medical infusion device is designed in this research which can conquer the disadvantages by introducing a
wearable auto-heat skin temperature controlling device, a video monitoring system and an omnidirectional moveable supporting device.

The whole design of the structure of this intelligent medical infusion device is shown in Fig. 6. At present, an experimental prototype has been produced, as shown in Fig. 7. This new kind of infusion device can promote the development of medical devices. Hospitals and clinics can be transformed to fit this design with a low cost. By this infusion device, the medical experience of patients and public praise of hospitals which applies this device will be improved.

Figure 6. The Design of the Intelligent Medical Infusion Device.
REFERENCES

1. Yang J., "Research Progress on relevant factors of venous transfusion", Chinese Nursing Research, 2005(7b), pp. 1125-1126.
2. Dong S., Wang J., Pan Q. and Cheng J., "Research Progress on new Intravenous Infusion Technologies", Chinese Journal of Nursing, 2003(9), pp. 719-721.
3. Zhang W., "Design of an infusion with constant temperature heating function control alarm", Electronic Design Engineering, 2005(15), pp. 23-25.
4. Cao H., "Design of infusion System Based on single chip", Popular Science & Technology, 2012(9), pp. 22-23.
5. Liu Q., Zhou X., Li C. and Zhao Y., "The Design of Intelligent Infusion Monitoring System Based on Mobile Micro-Network", Software Engineering, 2016(10), pp. 37-39.
6. Shi H. and Hu R., "Design of Smart Control System for Infusion based on Wireless Module PTR8000", Microprocessors, 2013(5), pp. 70-72.
7. Li Z., Yu X., Chen G. and Lu G., "The design of monitoring System for Venous Transfusion Based on MCU", Medical Equipment Information, 2006(6), pp. 13-14.
8. Diao H., Zhan X. and Ji B., "Development of Supervisory Control System of Intravenous Transfusion", Nursing Journal of Chinese PLA, 2009(2a), pp. 73-74s.