A Portable Intelligent Bladder Irrigation Device for Long-Term Care Management Center Patients

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***Abstract*—Urinary tract infection (UTI) is the most common nosocomial infection in many hospitals, accounting for 30% to 40% of all nosocomial infections. About 90% of them are related to long-term indwelling catheters, such as long-term care patients, diabetics, pregnant women, patients with Parkinson's disease, cortical stroke, brain tumors. Bacterial invasion of the human urinary system caused by inflammation of the bladder causes the bladder cells to induce cytokine secretion, including IL-1α、β、TNF-α, IL-6, IL-8 and IL-10, resulting in leukocyte aggregation, bleeding, and edema. This condition can lead to chronic nephritis, and severe cases can develop sepsis and even death. In this study, we developed a portable intelligent irrigation device based on activated carbon to assist the long-term use of urinary catheters in patients. Its principle works mainly through the activated carbon itself. The developed device has a large specific surface area and adsorption properties and can inhibit bacterial growth, while the adsorption of bacteria produced by internal and external toxins can slow down the pathogenicity of bacteria in organisms.**

Keywords-bladder irrigation; urinary tract infection; activated carbon.

I. INTRODUCTION

Bladder irrigation is a procedure in which sterile fluid is used to prevent clot retention/ infection by continuously irrigating the bladder via a catheter. Irrigation fluid management requires timely application of the right amount of detergent solutions. Competition for solutions, limited liquid resources and concerns for patients are making good irrigation management a challenge. In the world, Urinary Tract Infection (UTI) is the most common nosocomial infection in many hospitals [1][2]. Therefore, irrigation is a priority. However, poorly designed and planned irrigation management procedures and practices undermine the efforts to improve patients health and exposes people and the environment to risks. Many hospitals could benefit from having a proper irrigation schedule in place.

Just the right amount of irrigation needs to be determined. Too little irrigation can cause UTI; on the other hand, irrigation that is done too frequently can cause damage of the mucous membrane. There are many types of irrigation systems available on the market. The most common type is Continuous Bladder Irrigation (CBI) and it is a supplementary approach for irrigation management after surgery in order to prevent clot retention, cystospasm, and hemorrhage postoperatively. Although CBI is widely used to prevent clot retention and infection, it is not easy for nurses to transport the CBI device and bring it to each patient. Nurses are responsible for ensuring a continuous flow of prescribed solution during the whole procedure. Thus, it is imperative to assess the blocked catheter by checking the color of the drainage bag and controlling the flow rate. Currently, the flow rate of irrigation fluid is controlled manually by a nurse according to the color of drainage fluid. In this study, digital controllers using microcontrollers and analog controllers will be developed. These controllers are based on the measurement of the bladder tension. There are many types of sensors on the market that can be used to measure the tension, such as [3]. Some of these sensors are based on the resistance principle and some are based on the capacitance principle. Complementary Metal Oxide Semiconductor (CMOS) technology [3] is one of such technologies, which benefited from the communication and computing technologies. It should be pointed out that medical devices may themselves not require the sub-micron scaling of the CMOS technologies, but such developments, which generally serve in the first place for research purposes, can easily be translated into a medical device application. Further, claims of the field are shaped by biological media as novel resources. In this study, the integration of CMOS devices with various emerging sensing elements, utilizing techniques, such as surface activation by chemical means is quite promising in the field of research involving the development of CMOS-based sensors for bladder irrigation devices. The rest of the paper is structured as follows. In Section II, we present the materials and fabrication method. In Section III, we show the results and discussion. Finally, we conclude in Section IV.

II. MATERIALS AND FABRICATION METHODS

Bladder irrigation is one of the most effective measures to prevent urinary tract infection in patients with long-term indwelling catheter [4]. The operation of traditional artificial bladder irrigation is complicated and needs constant monitoring. Based on traditional artificial bladder irrigation technology, a kind of intelligent bladder irrigator and its control system are designed. The control system includes Programmable Logic Controller (PLC) and touch screen. By using a weighing sensor to monitor the weight of the infusion bag in real time, the irrigator control pinch valve can switch the infusion tube automatically. Bladder irrigation can be carried out automatically by using this intelligent bladder irrigator.

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In order to assure a clean environment and to minimize the possible influence of environmental conditions in the experiments, a measurement cell was designed and fabricated. The use of this microfluidic chamber minimizes both the sample volume and the amount of reagents needed for detection, reducing thus the cost of the assay.

III. RESULTS AND DISCUSSION

The portable intelligent bladder irrigation device is the main part of the electronic system and its duty is to apply an electrical voltage and convert the electrochemical signal between the electrodes into an analog input. Figure 1 shows the device contains an analog digital converter ADS1256 from Texas Instruments (ADC), which turns the signal and sends it to the microcontroller composed of a FreeScale MC56F8037 commercial card (DSP, Digital Signal Processor). Finally, the data is sent to the control software by means of a USB connection.

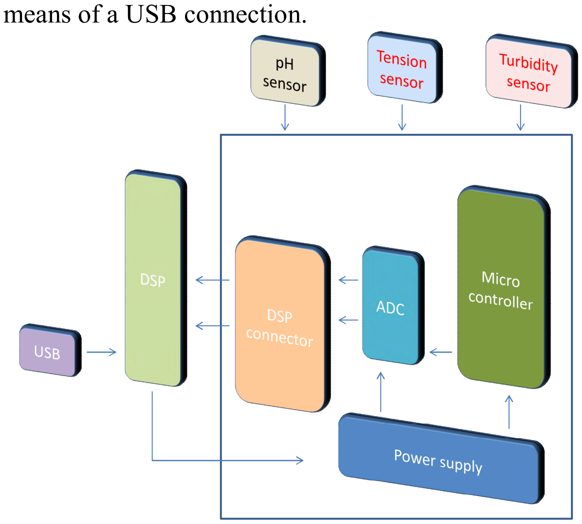

Figure 1. The electronic system

In order to integrate the intelligent bladder irrigation device with electrical connection pads, we have realized an integration scheme, in which the microchip is squeezed between a custom PolyMethylMethAcrylate (PMMA) fluidic adapter and a Printed Circuit Board (PCB), as shown in Figure 2. The electrical connections were realized between the electrical pads of the fabricated chip and the PCB, in which the conductive layers are oriented vertically in the thickness direction, making contact from top to bottom. These connectors prevent the use of fragile bond wires that may compromise fluidic integration, as well as the larger footprints that are required when using spring loaded connectors. Moreover, using the given integration scheme, the device replacement can easily be done within a minute.

For men or women, a bladder irrigation device measures the Escherichia Coli in the bladder, urethra, and abdomen. A catheter in the bladder fills the bladder with fluid and measures Escherichia Coli in urine. Another catheter, placed in the vagina for women or the rectum for men, reflects the Escherichia Coli in the abdomen. A bladder irrigation device can reveal detrusor over activity, stress incontinence from sphincter weakness, or weak pelvic floor muscles. Figure 3 shows the number of E.Coli could be reduced by the bladder irrigation device.

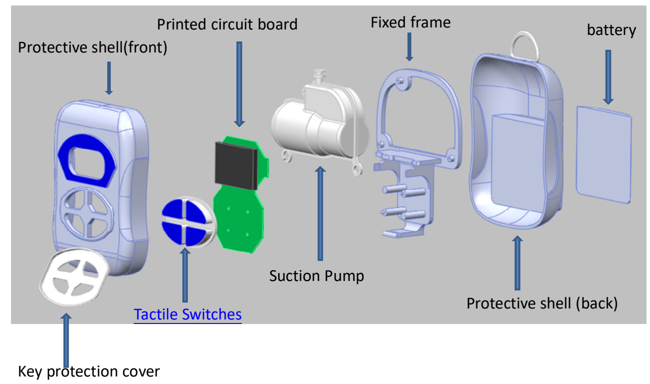

Figure 2. The bladder irrigation device

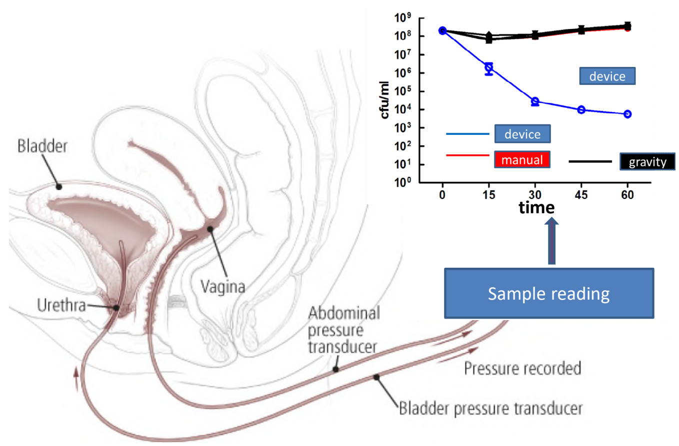

Figure 3. The bladder irrigation device measures the Escherichia coli in the bladder

IV. CONCLUSION

In this work, we have demonstrated an intelligent bladder irrigation device and a CMOS sensor to detect E. Coli in an artificial urinary bladder. It was capable of performing detection in an automated fashion while consuming fewer volumes of reagents using activated carbon.

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