UMOD: A Device for Monitoring Postoperative Urination

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Abstract. A Urine Monitoring Device (UMOD) has been designed and implemented for monitoring postoperative urination. This device has been created primarily to assist nurses and doctors monitor patients during their postoperative and recovery period. Furthermore, to reduce the burden of the nursing staff required to regularly monitor and empty the urine bags saving them precious time. The device consists of a stand and a load cell where the urine bag is attached. The stand is light and can easily move shall the patient require to move. An ESP Wi-Fi microprocessor module is used to calculate the rate of flow of urine in real time, identify and ignore any false readings due to accidental movements of the urine bag using an accelerometer and transmit the readings to a server / cloud through the local Wi-Fi.

Keywords. Monitoring, Urine, Postoperative Urination, Fluids, Medical treatment

Introduction

The number of different medical related conditions treated on a daily basis in hospitals is enormous, requiring constant attention from hospital staff, resulting in pressure, tension and in some cases mistakes. Rapid changes in medical technologies together with changing practice pattern of doctors can be employed to improve the time spent by nurses and doctors. Today's medical technology is more advanced and effective while there is strong demand for even more advanced diagnostic technology and therapeutic equipment. Development of such technologies is the way forward towards a more effective and accurate healthcare system. Nevertheless, technology can improve healthcare and treatment by improving simple everyday life tasks of patients. This has become even more apparent given that there is high demand for increased productivity despite financial reductions. As stated in [1], "Expensive technology is a bargain if it can improve quality of life, preserve economic productivity and prevent the high cost of disability". This paper presents how a prototype of a low-cost Urine Monitoring Device (UMOD) has been developed and how this can be used for patients fitted with a urine catheter. The device has been designed to provide constant, real-time information about the rate of flow of urine in the bag. The rate of flow of urine is particularly useful to the medical staff given that there are many illnesses related to the urine system such as chronic kidney disease, bladder diseases, urine system pathologies, etc. Most importantly, UMOD can be used to monitor the patients' ability to urinate postoperatively given that there are numerous factor that can influence this ability such as (a) age, (b) gender, (c) a

previous history of bladder problems, (d) type and duration of surgery and anesthesia, (e) drugs, and (f) intravenous fluids [1]. In such cases, our device can be used to provide useful information to the doctors regarding the frequency and the volume of urine flowing out of the body of the patient.

1. Proposed Low-Cost Urine Monitoring Device

The objective of developing a low-cost urine monitoring device is to facilitate the mass deployment of such devices in hospitals in order to collect useful information from patients suffering from urinary related diseases and support their postoperative treatment. Also, to reduce the burden of the nursing staff to check the urine bags at frequent time intervals by alerting the nurse station with the help of an alarm system so that a suitable action can be taken. Furthermore, to intergrade these devices to a healthcare system. In 2014 Abraham Otero et.al. designed and built a similar device capable of automatically monitoring of urine output [3]. The device provided minute by minute measures and it could generate alarms that warned of deviations from therapeutic goals. Their device had a single-chamber container holding 90ml. The urine ended up in the vessel through a tube attached to the catheter and outside it had a capacitive sensor. This capacitive sensor was used to measure urine levels in the container. So, when this pot was filled, it was emptied automatically without the need of electricity. To do this, however, their device used magnetic forces to prevent activation of the dispenser until it is almost full. In addition, BIOMETRIX built a device called URIMETRIX for measuring the urine output and calculates the volume of urine every time the patient urinates and then dispose the urine in a bag [4]. This allows closer monitoring of the patients given that it is possible to measure the ratio of urine density compared with water density and provide information on the kidney's ability to concentrate urine. URIMETRIX includes high level urine meters, foley catheters with temperature sensor and intra-abdominal pressure sets with accurate pressure transducer monitoring. UMOD features a much simpler and lower-cost mechanism where the weight of the catheter's bag is constantly measured and any increase / decrease on the weight of the urine bag is timely recorded. No special urine bags are required nor tubes. Assuming an average density of the urine, it is possible to calculate the quantity of urine flowing into the bag in milliliters. Nevertheless, for some conditions, there is high urine specific gravity, such as in the cases of volume loss (dehydration, vomiting, diarrhea, fever), hepatorenal syndrome, heart failure, renal artery stenosis, shock syndrome of inappropriate antidiuretic hormone. For some other conditions such as diabetes insipidus, renal failure, pyelonephritis, glomerulonephritis, psychogenic polydipsia, malignant hypertension there is low urine specific gravity. In such cases using a urinary specific gravity measurement is a routine part of urinalysis. Nevertheless, this exceeds the scope of UMOD given that it is designed to provide readings assuming an average urine density thus making it applicable for conditions that do not affect the urine specific gravity and simple monitoring of postoperative urination is critical for the recovery of the patient [5].

UMOD System Requirements

The Urine Monitoring Device was designed based on a set of requirements provided by nurses and doctors. More specifically, the UMOD's cost had to be kept as

low as possible to support the mass deployment such devices around a hospital. UMOD should be light in order to be easy to move. It should constantly measure the weight of the urine bag (ignoring the actual weight of the bag) and transmit the data to a local server / cloud for further processing. Furthermore, UMOD should be easy to set up for users (primarily nursing staff) with no particular ICT skills. Furthermore, the device should also be capable of ignoring any sort of accidental movements of the urine bag. The device should also be fixed either on the side of the bed or on a separate floor stand given that some patients might wish / have to move out of their bed. The device should allow nursing staff to easily empty the urine bag.

UMOD Hardware / Software Design and Operation

Operation of UMOD is based on a load-cell that constantly measures the weight of the bag and transmits the readings to a local server / cloud running a database to keep track of each patient urination (time, weight / volume). More specifically, the device is using an ESP (Wi-Fi) microprocessor module which is connected to a load cell. The load cell is used to measure the weight of the urine bag and it can provide readings up to 2kg. The analogue signal from the load-cell is amplified and then received by the ESP where it is then transmitted through the Wi-Fi to a local server or cloud. The load cell is attached on the stand that is to be situated next to the patient's bed. A hook connected on the load cell allows the urine bag to be attached. Using the readings recorded in the local server / cloud, it is possible to calculate the rate of flow of urine per hour. These readings can be particularly useful for checking the frequency and quantity of urination of a patient assuming average urine density. Finally, an LCD screen is connected to UMOD where someone can see the current reading of the urine weight. UMOD is set to ignore the weight of the empty urine bag, thus providing readings only of the content of the bag. UMOD is also facilitated with an accelerometer in order to record potential movements of the urine bag. The accelerometer has been (externally) attached near the end of the urine bag (see Figure 1and Figure 2).

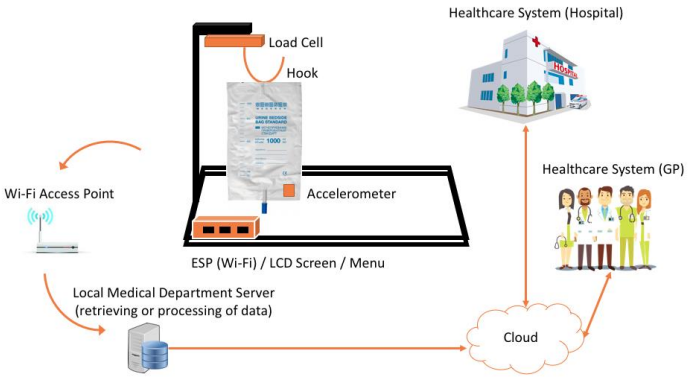

Figure 1 Proof of concept of UMOD integrated with a Healthcare System

Figure 1 illustrates a proof of concept of how UMOD will be integrated with a health care system providing useful information about the state of the patient in terms of urine output. Typically, this data will be made available to the medical department the patient is treated through a local server, as well as to the cloud for external access through the healthcare system of the country.

2. Discussion of Results

A number of initial tests were devised to verify the operation of the device. The most basic test was to connect a bottle of water to the urine bag and manually allow water to flow in the bag. Figure 2(a) illustrates the actual prototype and Figure 2(b) the data recorded by UMOD when urine (water) was released in the catheter on the 13th minute and the weight measured was 0.105 kg (0.105L). Another release took place on the 14th minute where the weight moved up to 0.200 kg (0.2L). The next release took place on the 22nd minute and the weight increased to 0.420 kg (0.42L). All instances were cross-checked for validity using a precision weighing machine as well as based on the quantity of the water poured into the urine bag. Another test that took place after the 30th minute was the shock-test where the catheter's bag was intentionally moved to check if the value of the weight recorded has changed but as it can be seen, the readings remained the same. In this particular example it can be deduced that the patient produced a total of 0.42L of "urine" in an hour. This will become more meaningful when data is collected for longer periods, and particular urine release patterns are recorded to estimate the rate of flow.

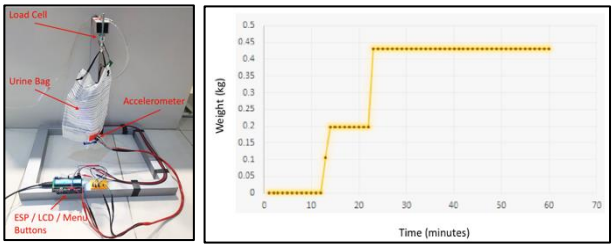

Figure 2 (a) UMOD Prototype (b) Results Water filling and shock test of UMOD

3. Conclusions and Future Work

A simple yet effective urine flow monitoring system called UMOD has been devised. UMOD constantly monitors the levels and rate of flow of urine in a urine bag and reports this in a local server / cloud for further processing. UMOD assumes that urine density is constant in order to estimate the rate of flow in milliliters. UMOD demonstrated that its operation makes it an ideal low-cost device for monitoring postoperative urination. Next step is to develop a mobile app for better user experience and an API for our devices so that this data can be integrated with existing healthcare systems.

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