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DESIGN OF AMBULATORY URODYNAMIC SYSTEM USING DSP PROCESSOR

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Abstract: Urodynamic study system is widely used for neurogenic bladder patients in various clinical setting. Generally they include 2 pressure sensors from bladder and rectum, and 1 EMG sensor. The rectal pressure catheter is often the source of data error because of gas passage and the fall out of the catheter from anus, and source of discomfort in ambulatory urodynamic system. The aim of this study is to design and calibrate the ambulatory digital urodynamic study system that can discard the rectal pressure catheter, which can make patients more comfortable and doctors can get more physiologic data. As a first step, we compared our new system with Dantec Duet ™ urodynamic system (Dantec, Denmark) and tried to see the possibility of our new system.
Key words: urodynamic study, rectal pressure, catheter, EMG sensor

Introduction

Urodynamic study is an examination of dynamic and functional activation, and of analyzing the relationship of one. Using the data generally include intra-vesical pressure, urethral pressure, EMG and uroflowmetry obtained by the test urodynamic study can objectively analyze the physiological function and condition of a patient on lower urinary tract which can not be analyzed by inquiry or endoscopy. So this study is used for important information to decide medical treatment method of micturition disorder.

The urinary organs' trouble is one of the rapidly increasing old men's diseases with the fast increasing of aged population. Therefore, to grope for medical treatment method of micturition disorder is urgently required.

The conventional urodynamic study system has several weak points. Most of those tests are performed with lithotomy position and so can't reflect the change of intravesical pressure and vesical function according to each of position change. And because of big scale of the equipment when performing the study, there is troublesomeness for patients to move to urodynamic study lab. Using a certain device, the examination includes the process to fill a bladder with a saline solution and so often make patients unpleasant. Moreover, those are expensive and impose a heavy burden on the patients.

Portable urodynamic study is technique to measure bladder function (bladder pressure, urethral pressure, detrusor pressure) using digital method. Accordingly, we will calibrate and design portable digital urodynamic system that can discard very large existing system, replace complicated study method and store pressure data for 24 hours. Therefore we devised this system and compared with Dantec Duet™ urodynamic system (Dantec, Denmark), existing urodynamic system, to calibrate. However, it is yet to be completed and clinical examination is not performed.

Materials and Methods

System design

Our system measures vesical pressure and urethral pressure inserting catheter sensor into bladder directly. Obtained pressure data was amplified at analog amplifier instrumentation amp02) and was converted into digital data. This data was stored in memory and was displayed by LCD. In order to analyze, data stored to memory was transferred into computer with maximum 700 Kbyte/sec speed and we analyzed intra-vesical pressure and urethral pressure using statistics program or other program. The follow figure 1 is whole block diagram.

Figure 1: Block diagram

USB controller used in our system was FT245BM to transfer pressure data. This USB could be used at both 1.1 and 2.0 system to transfer and receive 128 Byte data at computer. Directly in case of accessing, this device had transferring speed maximum 700 Kbyte/sec and in case of using vitual comport, it was transferred speed of 300 Kbyte/sec. A/D converter was used AD7859L. 3-channel analog signal received from sensor is converted into digital signal by A/D converter. And this signal was transfered at TMS320C31 processor. DSP processor has maximum 8 channels which were restricted from 0.5 V to 3.5 V to consider input level received from sensor. To match impedance of analog signal, this system used instrumentation amp02 and to remove 60Hz noise, used 60Hz notch filter. Also to remove offset-voltage generated from sensor used circuit.

Data memory was a device to store the input signal received from sensor. This memory was wholly consist of 16 bit. It had a 12Bit data received from A/D converter. The rest of the 4 Bit data could be used protocol header. LCD displays patient's ID, study date, pressure signal. The figure 2 is our devised portable digital urodynamic study

system. The circuit on left side illustrated on figure 2 is analog part and on the right side is digital part.

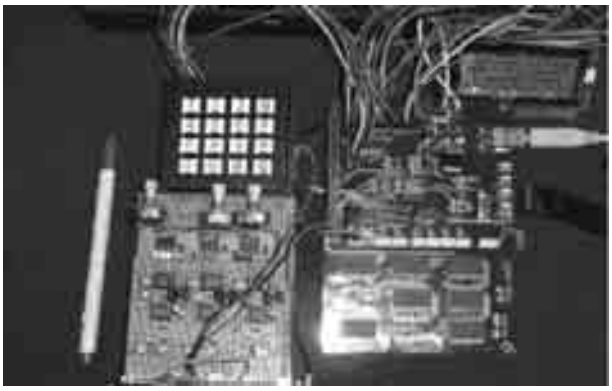

Figure 2: Devised urodynamic study system

Calibration

The follow figure 3 is calibration kit (DTP9022-K0122^{TM}). The signal measured from the sensor is obtained by moving slowly from 0 cmH_2O (the height is same as the top of tube) to 100cmH_2O for 90 second. This signal is transferred at computer or displayed by LCD with pressure unit.

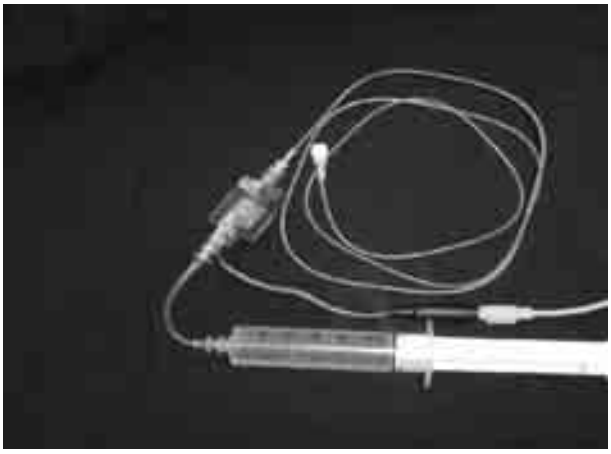

Figure 3: Calibration Kit

Also the calibration inspected our system adding to motion artificial noise responded to unexpected pressure change. As following table 1, we adjusted gain of amplifier with increasing pressure signal.

Protocol

- Adjust sensor signals as following table 1.
- Change the height of water-tube and store generated voltage in the memory of digital part.
- Transfer them to computer by USB when requesting and display pressure(cmH_2O) by LCD

Table 1: Gain adjustment according to pressure

Voltage	0.5V	3.5V
Pressure	0cm H_2O	100cm H_2O

System uniqueness

The existing urodynamic system had 2 pressure sensors to measure intra-vesical pressure and urethral pressure and 1 rectal catheter inserting into rectal to measure abdominal pressure. But our study replaced rectal catheter with EMG signal and forcibly injecting physiological saline into a bladder with using naturally filling urine.

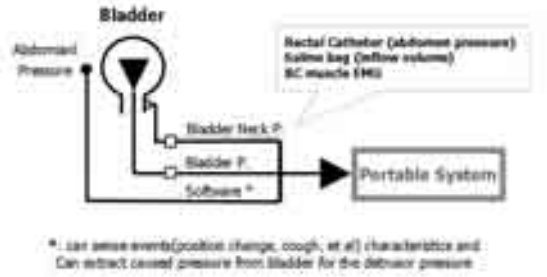

Figure 4: System uniqueness

Results

The Figure 5 is to display the pressure signal using a Matlab ^{TM} 6.5(Mathworks, USA). The signal was filtered with 2Hz low-pass for removing motion artifact noise. The blue line shows raw data and red line shows filtered data by 20 points smoothing method in order to remove the noise signal. It was possible to get the pressure values between 0 and 100cmH2O. The noise signals detected were due to motion artifact.

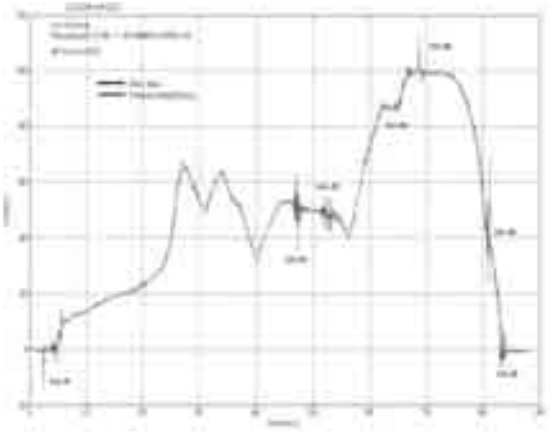

Figure 5: Measured pressure data between 0 cmH_2O and 100 cmH_2O

Conclusions

Calibration results showed that our devised system is very similar with Dantec Duet^{TM} urodynamic system (Dantec, Denmark). In order to make more stable ambulatory system and be cheaper, it is necessary to use ASIC technique and remove the noise in detail. And getting rid of rectal pressure catheter will be possible in the near future with the use of software that can extract abdominal pressure

change due to inadvertent events (position change, cough and so on) from bladder pressure.

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