Automatic Control of Electrodes in Lithotripsy Machine

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Abstract

Extracorporeal shock wave lithotripsy (ESWL) employs high-energy shock waves that propagate through the body and focus on the stone to break it into small grains, which travel out of the body along with the urine. The distance between lithotripsy long-life electrodes tends to vary after every session. This variation causes an associated pain for the patient, and hence the need for re-calibration and adjustment of the distance. Both manual calibration and adjusting procedure are time wasting, inaccurate, and must be performed by an expert operator.

In this paper, a mathematical model has been developed to predict the number of shocks needed for every patient, depending on input information regarding his age, stone size, and location. An automatic adjustment procedure for the distance between electrodes, utilizing a proportional integral derivative controller, is also proposed in order to increase treatment effectiveness and to reduce patient pain. This also enables better planning of treatment and allows the possibility for any operator to use, and thus resulting in a better utilization of apparatus. Results from trials in a hospital were adequate, and the experimental data matched those predicted by the model.

Keywords: Solar Still; Lithotripsy; Kidney Stones; Shock-Waves.

1. Introduction

Extracorporeal Shock Wave Lithotripsy is a technique for destructing stones in the kidney and ureter into smaller particles that can be disposed of by the urine system, and this spares the patient the agony of surgery. This technique still imposes some pain and problem in the planning procedure [1]. Several researchers have proposed models to reduce the amount of pain and wasted time accompanied this process [2, 3]. There are two main types of lithotripsy electrodes which are used in hospitals and clinics: the first type is the disposable electrode shown in Figure 1a, which has the function of discharging the electrical shock wave, and this type is used for only one session. The other type is the adjustable electrode, shown in Figure 1b and known as the long life electrode where it can be used up to 50 sessions. Both electrodes could be either flat or conical depending on the electrode shape. In this paper, the second type has been investigated where a new method for automatically adjusting and controlling the distance or the gap between the electrodes is presented (Refer to Figure 1).

At present, the non-disposable long life lithotripsy electrode gap is adjusted manually by the doctor or the physician where it can be performed by placing a calibrated and a well-known thickness of metal sheet directly in the gap between the electrodes heads and manually adjusting the venire to the desired thickness [4]. This process is time consuming and exposes the patient to more pain than necessary. The main objective of this research is to introduce a scientific and a reliable way to automatically control and adjust the long life electrodes. This should increase the treatment effectiveness and further reduce patient's pain.

Figure 1. (a) Disposable Electrodes, and, (b) Non disposable Electrodes [5].

2. Treatment Process

The process of removing a stone from the kidney or from the ureter without the need for an open surgical technique is known as lithotripsy, which is a non-invasive surgical technique. The technique involves disintegration of the stone in vivo, so that it can pass through the urinary tract in the form of small particles, the passage of which doesn’t result in sever discomfort or disability. The treatment process can be planned ahead depending on patient weight, sex, and type of stone [2, 3]. This planning