Chapter 13
New Features Extracted From Renal Stone NCCT Images to Predict Retreatment After Shock Wave Lithotripsy (SWL)

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ABSTRACT

Shock wave lithotripsy (SWL) is a noninvasive and safe treatment for small renal stones. In unsuccessful cases, retreatment procedures are needed after SWL. According to the previous studies, patient and stone descriptors are good predictors of SWL success. Some stone and kidney descriptors are measured from renal Non-Contrast Computed Tomography (NCCT) images. It is a tedious, time-consuming and error-prone process with large inter-user variability when performed manually. In this study, novel features are proposed automatically extracted from NCCT images to describe morphology and location of renal stones and kidneys to predict retreatments after SWL. The proposed features can distinguish between different kidney and stone morphologies and locations while being less sensitive to image segmentation errors. These features are added to other stone and patient features to predict retreatment within 3 months after SWL. The experimental results show that using the proposed stone features extracted from NCCT images can improve the accuracy of predicting retreatment.

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INTRODUCTION

The general perspective of the chapter is two folded. The first is introducing new features that can be extracted from NCCT images of kidney stones automatically. The second one is investigating whether the proposed feature set can improve the performance of predicting SWL retreatment for patients or not. In this study, the research problem is to predict whether the patients after SWL would need retreatment procedures or not. For solving this problem, new features are proposed which will be extracted from NCCT images by using automatic methods. These features describe renal stone and kidney morphology and location descriptors. Object morphology is defined as its shape and size characteristics (Sparks & Madabhushi, 2013). The descriptors extracted from NCCT images and other stone and patient features are considered in this study for predicting retreatment within three months after SWL. For this, data mining methods are exploited.

The main contribution of this study is to introduce novel features which are automatically extracted from NCCT images of renal stones. These features are added to other stone and patient features to predict retreatment within three months after SWL. The experimental results show that using the proposed features extracted from NCCT images can improve the accuracy of predicting retreatment after SWL. In this study, for evaluating the significance of variables on the SWL success, data mining classifiers such as decision tree, k-nearest neighbor, support vector machines and Naïve Bayes are used.

BACKGROUND

Shock wave lithotripsy (SWL) is the treatment of choice for renal stones smaller than 2 cm in the renal pelvic and upper or middle pole calyces (Tiselius et al.,2001), whereas percutaneous nephrolithotomy (PCNL) is recommended for large or complex stones (Skolarikos, Alivizatos, & Delarosette, 2005). SWL has been introduced by Chaussy et al. (Chaussy, Brendel, & Schmiedt, 1980) as a noninvasive and safe therapy for small renal stones(Lee et al., 2015).

Goktas et al. have shown that SWL is very successful in pediatric patients for lower calyceal stones (Goktas et al., 2011). They have evaluated SWL for adults and children. For this purpose, stone free rate and the need for auxiliary procedures after the first SWL treatment have been considered. The results showed that the stone free rate after the first SWL for children was 66.6% and they have concluded that SWL is very successful for children.

In some cases, larger fragments remain after renal stone primary treatment and retreatment procedures are needed. Retreatment is a subsequent intervention for the disease condition. If SWL treats the stones successfully, there is no need for retreatment and the stone is completely fragmented. Therefore, retreatment rate and/or stone-free rate after the primary renal stone treatment show how the stone treatment is successful (G.V. et al., 2003; Pareek, Armenakas, Panagopoulos, Bruno, & Fracchia, 2005).

Retreatment rate can be estimated via Kidney, Ureter and Bladder X-ray (KUB radiography), and NCCT images. In this study, two class labels are considered as positive (if the patient has retreatment rate within three months after SWL) and negative (otherwise).

Some researchers have proposed different methods for predicting the success after stone treatment methods (Alger, Niederberger, & Turk, 2009; Chen, Liu, Hsieh, & Wang, 2016; Resorlu, Unsal, Gulec, & Oztuna, 2012; Zhu et al., 2011). Zhu et al. have used univariate and multivariate analysis (using logistic regression) of different variables for predicting stone free rate after PCNL. They have considered