ISSN: 2689-8616

Case Report

Advancements in Journal of Urology and Nephrology

A Smart Computer Program to Assist Healthcare Providers in Selecting the Best Treatment for Patients with Urinary Stones

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Submitted: 2024, Jun 14; **Accepted**: 2024, Jul 10: **Published**: 2024, Jul 15

Citation: Noble, P. A. (2024). A Smart Computer Program to Assist Healthcare Providers in Selecting the Best Treatment for Patients with Urinary Stones. *Adv J Uro Nephro, 6*(1), 01-05.

Abstract

Urinary tract stones can obstruct the urinary tract, resulting in severe lower back pain, blood in the urine, vomiting, and painful urination. While small stones can pass naturally through the urine stream, larger ones necessitate fragmentation with shock wave lithotripsy (SWL) or laser ureterorenoscopy (URS) to prevent urinary tract blockage. A smart computer program was developed to predict treatment efficacy and potential complications for individual patients based on factors such as age, health conditions, stone details, and treatment methods, ultimately recommending the most suitable option. Here, I present three case studies and their predicted outcomes.

Keywords: Urinary Stones, Shockwave Lithotripsy, Laser Ureterorenoscopy, Stone Fragmentation, AI Predictions

1. Introduction

Stones in the urinary tract are becoming more common worldwide, likely due to shifts in dietary habits and climate change [1]. These stones form when certain substances in the urine, such as calcium, oxalate, and/or uric acid, become highly concentrated and clump together in the urinary tract. While small stones, typically around 4 millimeters or less, can pass out of the body through the urine stream, larger ones may become lodged in the urinary system, causing symptoms like severe lower back pain, blood in the urine, vomiting, and painful urination. It is estimated that approximately 11% of people in the United States will experience a urinary tract stone at some point in their lives [2].

Physicians use shock wave lithotripsy (SWL) or laser ureterorenoscopy (URS) to fragment stones, facilitating their passage out of the body while minimizing treatment complications for patients, such as pain and bleeding. SWL delivers strong shock waves to the stone from outside the body, without causing harm to internal organs [3]. In contrast, URS is a more invasive procedure, involving the insertion of a small, flexible tube with a camera into the urinary tract to locate the stone [4]. Subsequently, a laser beam inside the tube fragments the stone into small pieces [5].

The effectiveness of SWL and URS treatments varies depending on factors such as the patient's health, age, body size, and the size, type, and location of the urinary stone [6-10]. For example, URS may entail more treatment complications and higher costs, sometimes requiring extended hospital stays compared to SWL [11,12]. Most patients tend to prefer SWL [13]. While a recent review by the National Institute of Health suggests that URS marginally outperforms SWL, SWL is generally considered more effective and cost-efficient [14]. Selecting the 'optimal' treatment for a patient is therefore not straightforward; an approach that helps physicians with these decisions is highly desired.

Using anonymous data accessible from the Kidney Stone Registry, we analyzed the treatment outcomes of 17,242 patients who have undergone SWL or URS treatments at multiple sites across the United States. Details of the approach and quality assessment of the AI models used to build the smart program can be found here: Refs [15,16].

2. Results

A smart computer program was designed to predict the efficacy of stone fragmentation treatments and assess potential post-treatment health issues [15]. The program considers various factors, including age, sex, weight, presence of health conditions like diabetes, prior medication use, and details about the stone such as size and location. Additionally, it considers the type of machines used for SWL and URS treatments. The computer program produces four

predictions: the likelihood of stone fragmentation for SWL and URS, as well as the probability of treatment-related health issues for each method. Additionally, it recommends the most suitable treatment for an individual patient. Three examples are shown below.

3. Case Presentations

3.1. Case 1

Patient: A 29-year-old woman with a BMI of 24 kg/m2 and no health problems.
Stone: In her left kidney, 14mm long and 8mm wide.
Medications: She has not taken any blood thinners.
Machines: Dornier Compact Sigma (SWL) and Lumenis Versa pulse 100 watts (URS).
Web interface for input data of this patient (Figure 1) [15].
The program output (Figure 2):

- **SWL:** 69.4% chance of breaking up the stone, 11.2% chance of problems.
- **URS:** 61.1% chance of breaking up the stone, 5.5% chance of problems.
- **Recommendation:** URS is better, with fewer expected problems.

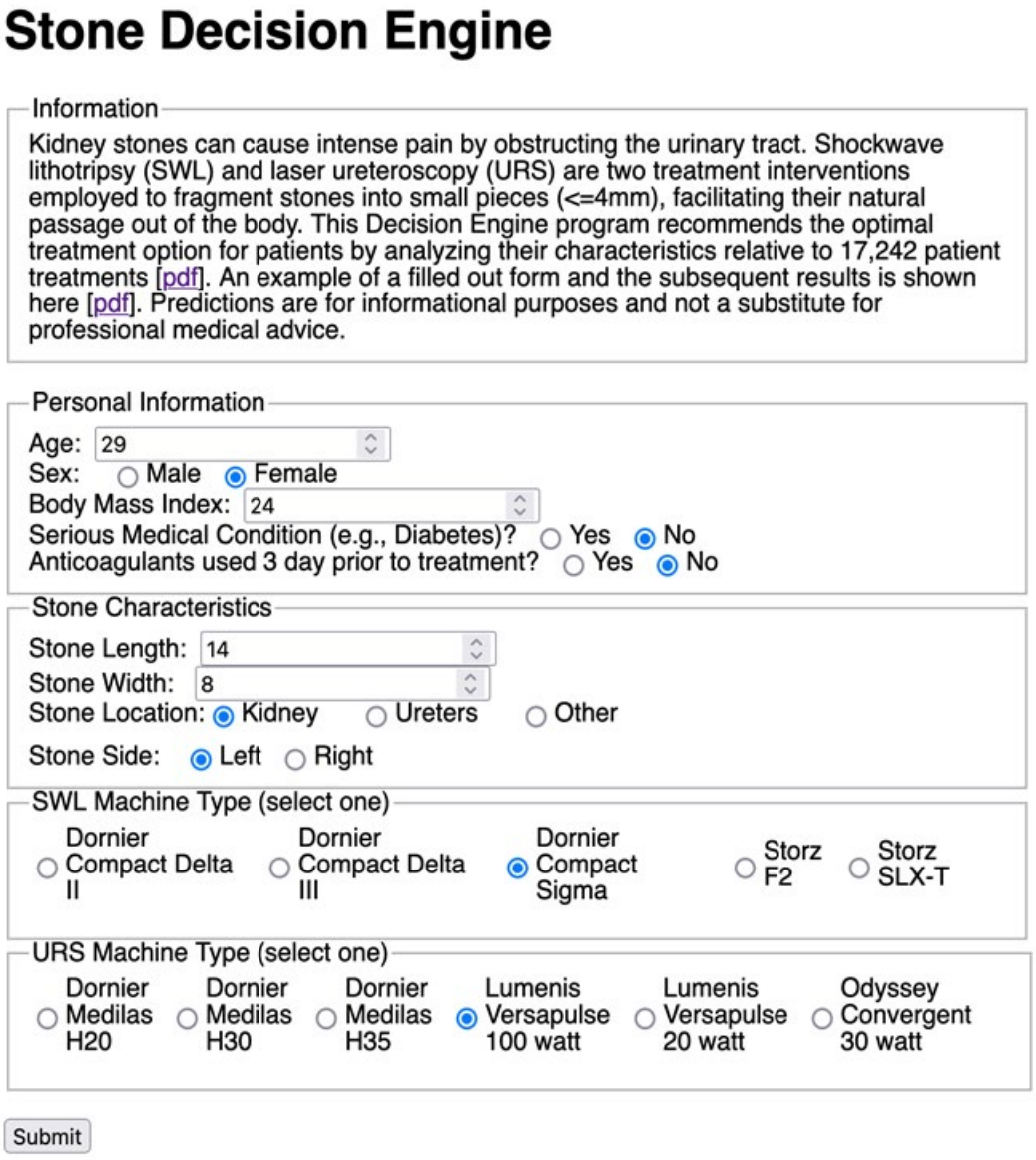

Figure 1: Screenshot of Web Interface Displaying Input Data for Case 1 Patient

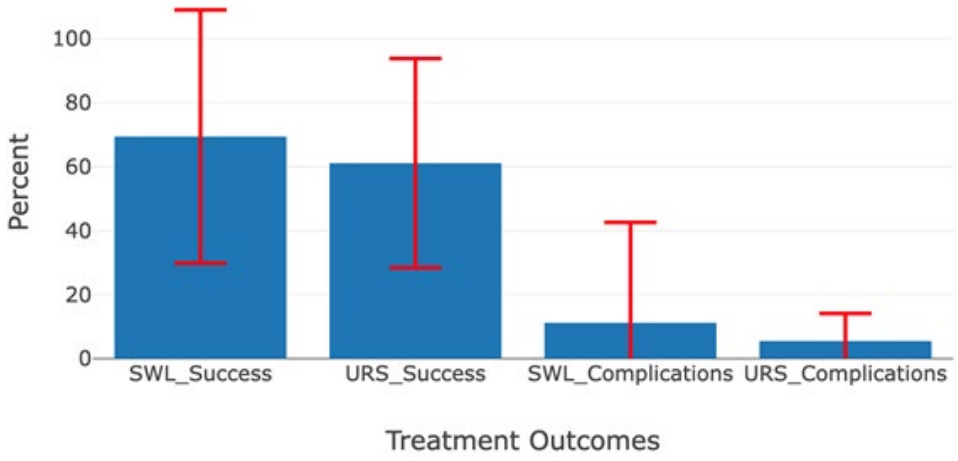

Figure 2: The average and standard deviation of predictions for stone fragmentation success (<=4mm) and treatment complications based on output from ten AI models for each prediction. URS has fewer treatment complications than SWL and is the preferred option

3.2. Case 2

Patient: A 45-year-old man with a BMI of 28 kg/m2 and no health problems.
Stone: In his right kidney, 10mm long and 10mm wide.
Medications: He has not taken any blood thinners.
Machines: Storz SLX-T (SWL) and Odyssey Convergent 30-watt (URS).

The program output (Figure 3):
• **SWL:** 94.7% chance of breaking up the stone, 2.4% chance of problems.
• **URS:** 100% chance of breaking up the stone, 0% chance of problems.
• **Recommendation:** Both SWL and URS are preferred options.

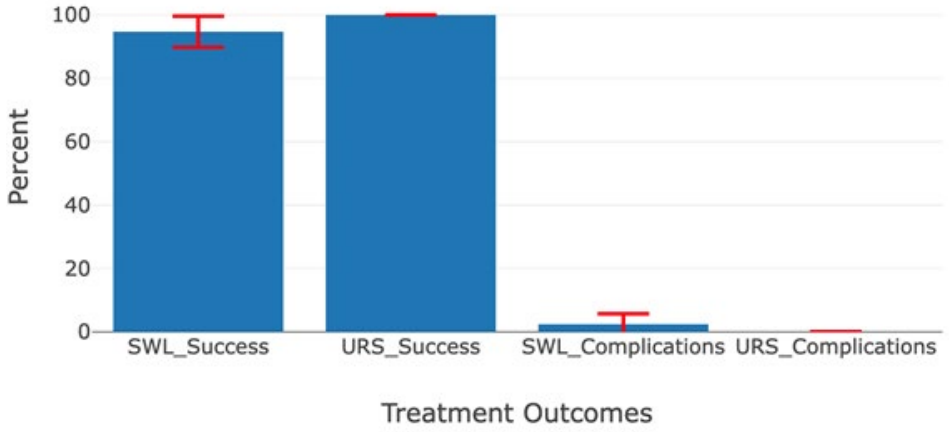

Figure 3: The average and standard deviation of predictions for stone fragmentation success (<=4mm) and treatment complications based on output from ten AI models for each prediction. Both SWL and URS are preferred options

3.3. Case 3

Patient: A 75-year-old woman with a BMI of 30 kg/m2 and health problems.
Stone: In her left ureter, 9mm long and 9mm wide.
Medications: She has not taken any blood thinners.
Machines: Storz F2 (SWL) and Lumenis Versa pulse 20 watt (URS).

The program output (Figure 4):
• **SWL:** 62% chance of breaking up the stone, 3.1% chance of problems.
• **URS:** 84.9% chance of breaking up the stone, 55.3% chance of problems.
• **Recommendation:** SWL is better, with fewer expected problems.

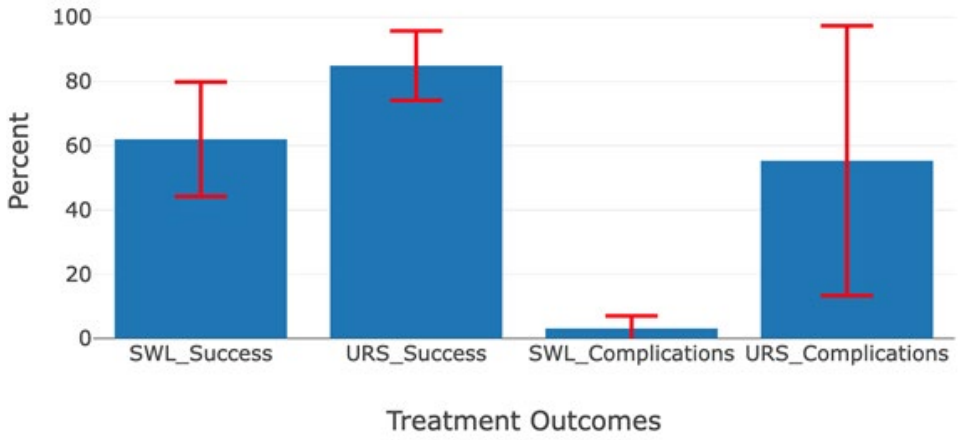

Figure 4: The average and standard deviation of predictions for stone fragmentation success (<=4mm) and treatment complications based on output from ten AI models for each prediction. SWL is the preferred option because it has a lower probability of treatment complications than URS.

4. Discussion

The motivation of this study was to demonstrate the utility of a smart computer program that predicts SWL and URS outcomes, aiding healthcare professionals in patient care decisions. The average prediction accuracies of the program for SWL stone removal and treatment complications were 84.8% and 95.0%, respectively, and for URS, the accuracies were 89.0% and 92.2%, respectively [16]. These predictions are widely applicable across institutions and physicians.

5. Conclusion

The smart computer program represents a groundbreaking advancement in predicting stone treatment outcomes for individual patients having a urinary stone. It leverages data from multiple institutions and diverse physicians, analyzing thousands of patients.

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