Computerized Decision-Making of Treatment Choices for Patients with Kidney Stones

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Introduction. Kidney stones can be found in an average of 10 - 20 of 10,000 people. Number of patients with kidney stones in developed countries is gradually increasing. One of the factors why this is happening is increased protein usage in the diet, inactive lifestyle or lack of fluid intake [3]. Simple cases of kidney stones can be dissolved using medications and stones will pass out by themselves. In more complex situations, it is necessary for multiple surgical procedures and patients may need to stay in hospital for several days [2].

Proposed method. To create computerized decision-making of treatment choices for patients with kidney stones guidelines of urolithiasis were used [2]. There are several steps to develop fully working software, starting from knowledge base creation and finishing with computer program testing.

Step 1. At the beginning all the possible diagnosis must be selected for patients with kidney stones. Kidney stones can be located in the urinary tract, kidneys and bladder. This paper provides decision-making in cases when stones are only in kidneys. In spite of it where kidney stones are, diagnosis are divided in two parts:

- Uncomplicated kidney stones (without infection);
- Complicated kidney stones (infectious);

In this case they really are only two, if not mentioning any of kidney stones features (composition, size, and location in the kidney). Problems start when it is necessary to choose the optimal therapy, where all stone features and indications, contraindications must be examined and used [2, 3].

Step 2. All possible therapies must be selected. Therapies can be divided in two groups:

- Conservative therapy;
- Surgical therapy;

Conservative therapy holds all types of drug treatment. Starting with simple analgesics and ending with oral chemotherapy. Surgical therapies are:

- Stenting;
- Extracorporeal shock wave lithotripsy (ESWL);
- Ureteroscopy (URS) or Retrograde Intrarenal Surgery (RIRS);
- Percutaneous nephrolithotomy (PNL);
- Laparoscopy;
- Open Surgery;

Afterwards priority table of treatment choices must be created using composition and size of renal stones. Unfortunately practice shows that renal stone features gives no information about patient, but this kind of information is crucial and must be used for decision-making. Each therapy got their own indications that allow using selected therapy but there can be one or more contraindications prohibiting selected therapy. Following table gives an example of one of the therapies (see Table 1) [2, 3].

Table 1. Extracorporeal shock wave lithotripsy indications and contraindications

Therapy	Indications	Contraindications
Extracorporeal Shock wave Lithotripsy (ESWL)	• Calcium stones smaller than 20 mm; • Cystine stones smaller than20 mm; • Diabetes; • Hypertension; • Respiratory diseases; • Patient with a single kidney; • Not allowed to use anesthesia and open surgery; • Patient who recently had a surgery;	• Pregnancy; • Severe skeletal malformations; • Arterial aneurysm; • Uncontrolled urinary tract infections (UTIs); • Severe obesity; • Non-functioning kidney; • Urinary stasis; • Prolapsed kidney; • Unsuccessful ESWL therapy; • Intrarenal anatomical abnormalities

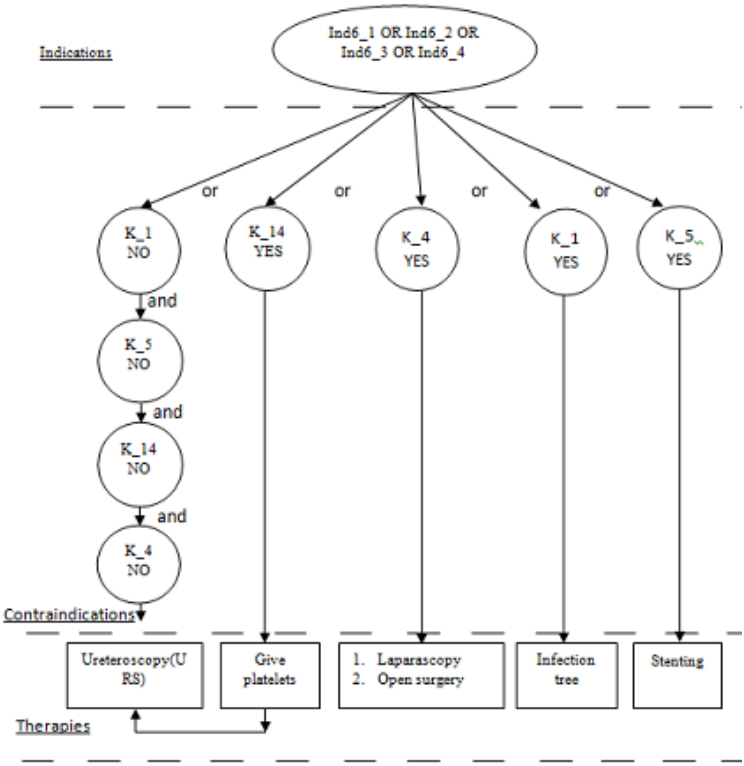
Step 3. Since the knowledge base structure is based on decision trees, information is stored using production rules. Production rules consist of a condition (IF) and action (THEN). Formally it is written: IF (condition) THEN (action).

Decision tree consist of decision nodes (Indications), chance nodes (contraindications) and end nodes (therapies). Decision trees must be created for each indication. To make this process easier all indications and contraindications were indexed and later these indexes were used during programming process. Indications and contraindications are indexed as one list, but used separately for each therapy. Ureteroscopy indication indexes are [1]:

- Ind6_1 – Unsuccessful ESWL therapy;
- Ind6_2 – Nephrocalcinosis;
- Ind6_3 – Severe obesity;
- Ind6_4 – Stones in kidneys and urinary tract at the same time;

And contraindication indexes are:

- K_1 - Uncontrolled urinary tract infections (UTIs);
- K_4 - Intrarenal anatomical abnormalities
- K_5 - Urinary stasis;



- K_14 - bleeding diathesis;

Ureteroscopy decision tree can be seen in Fig. 1.

Fig. 1. Example of decision tree

In order not to draw exactly the same four trees, where the only difference is decision nodes (Indications), it has been resolved by drawing a decision tree where all four indications are at the decision node (see Fig. 1) [1].

Step 4. Next step is to write production rules. At the beginning rules are written for each branch separately and later all possible branch combinations must be described. In order not to exceed page limit only some of the production rules are shown.

PR 1 (A branch) **IF** there is Ind_6 **AND** (no K_1) **AND** (no K_5) **AND** (no K_14) **AND** (no K_4)
THEN „Ureteroscopy"

PR 2 (B branch) **IF** there is Ind_6 **AND** (yes K_14) **AND** (no K_4) **AND** (no K_1) **AND** (no K_5)
THEN „Give Platelets" **AND** „Ureteroscopy"

PR 3 (C+D+E branch)	**IF** there is Ind_6 **AND** (yes K_4) **AND** (yes K_1) **AND** (yes K_5) **AND** (no K_14) **THEN** go to „Infection tree" **AND** „Use Laparascopy or Open Surgery"

By using the same principle decision trees are made for all indications and all possible production rules are written including all combinations between tree branches.

Step 5. All necessary information to create computerized decision making are stored in production rules. Production rules are coded and used in software. Software supports new patient registering by filling the application form. Software saves all test results and they can be viewed at any time by doctor. Patient data and test results are saved in database to ensure data security. Test must be performed step-by-step following to the given user manual.

Step 6. Last step is testing. Software was tested by using real life cases. The attending physician completed this test with real life situations and compared given decision of therapy with his own decision. After all given software was accepted as fully working. There are no fundamental mistakes in production rule logics because they were confirmed by certified urologist and signature with stamp was given.

Conclusions. To create computerized decision-making by using decision trees and production rules, one of the main tasks was to create synthesis between these two elements. One of the most important stages was knowledge formalization and structuring. Extensive knowledge of disease development and patient is needed to choose the optimal therapy. Fully working computer program has been developed and the attending physician can use and test it in practice.

References

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Computerized decision–making about treatment choices for patients with renal stones has been described step-by-step in this paper. Medicine is one of the sectors where computerized decision-making is being used more often. One of the key elements of expert systems – building a knowledge base that is based on recommendation fund, known as „Guidelines", is discussed. Paper contains the most frequently used therapies. Example of decision tree and production rules is shown.