Predictive factors of extracorporeal shock wave lithotripsy success for urinary stones

Facteurs prédictifs de succès du traitement des lithiases urinaires par lithotripsieextracorporelle

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RÉSUMÉ

Objectif : Déterminer, à la lumière de notre expérience, les facteurs prédictifs de succès de la lithotripsie extracorporelle pour les calculs urinaires.
Méthodes : Les dossiers de 68 patients porteurs de calcul urinaire traité par lithotripsie extracorporelle ont été étudiés. Les paramètres analysés sont : l'âge, le sexe et l'indice de masse corporelle des patients ainsi que la taille, la densité en unités Hounsfield sur le scanner des calculs traités et leur composition chimique déterminée par l'analyse spectrophotométrique par infrarouge.
Résultats : La densité du calcul et la composition chimique sont les seuls facteurs prédictifs de succès de la lithotripsie extracorporelle. Les calculs avec une faible densité en unités Hounsfield sont les mieux fragmentés. Le seuil de densité permettant de distinguer entre les deux groupes de succès et d'échec de la lithotripsie extracorporelle est de 1000 unités Hounsfield. Les résultats de la lithotripsie extracorporelle sont meilleurs avec les calculs d'acide urique et ceux d'oxalate de calcium dihydraté.
Conclusion : Dans notre série, la densité du calcul sur le scanner et sa composition chimique ont une valeur prédictive significative dans la prédiction de succès d'un éventuel traitement par lithotripsie extracorporelle.

Mots-clés
lithiase ; lithotripsie extracorporelle ; facteurs prédictifs.

SUMMARY

Objective: To review with our experience the predictors of stone-free status after extracorporeal shock wave lithotripsy (ESWL) on urinary stones.
Methods: The records of 68 consecutive patients with urinary stones treated with ESWL were reviewed. Patient age, sex, body mass index (BMI), stone dimension, stone Hounsfield density (HD) and stone composition determined by infrared spectroscopic analysis were studied as potential predictors.
Results : Stone Hounsfield density and stone composition were found to be the only predictors of treatment outcome. Stones with lower mean HU levels were more successfully fragmented. The stone density threshold that best distinguished between the outcome groups was 1000 HU. Higher ESWL success rates were found with uric acid and calcium oxalate dihydrate stones.
Conclusion : results of our study have shown that stone Hounsfield density and stone composition predict for ESWL success.

Key-words
Stone, extracorporeal shock wave lithotripsy, Predictive factors

ESWL remains the first line treatment for upper urinary tract stones (1). While it is safe and non invasive, treatment may result in unnecessary renal trauma, acute renal injury, hemorrhage, pain and the requirement of an alternative treatment procedure which increases the medical costs. Therefore, stone fragility should be predicted before starting treatment.
In this study, we retrospectively, investigated the predictors of ESWL success including patient characteristics, stone Hounsfield density and stone composition.

METHODS

A retrospective study of 68 consecutive patients underwent ESWL for urinary stones, from May 2008 to May 2013, using an electromagnetic lithotriptor made in Germany (SIEMENS MODULARIS Litho Vario) were performed. Inclusion criteria included having ESWL as the initial stone treatment; a solitary renal or ureteral stone between 5 and 20 mm. Exclusion criteria included patients with mid and distal ureteral stones and those with uric acid stones who received medical treatment. In each treatment the maximum number of shock waves was limited to 3000 for renal stones and 4000 for ureteral stones.
Thirty-six patients underwent pretreatment non-contrast-enhanced computed tomography (NCCT), the others had excretory urography. A total of 12 patients underwent a single ESWL session, 23 patients underwent 2 sessions and 33 patients underwent 3 sessions. In our department, patients are routinely asked to strain all urine throw a filter in the first 48 hours after ESWL and bring the fragments for stone analysis. The Hounsfield Unit (HU) density for each stone was determined. KUB x-ray and abdominal ultrasound were performed at 3 months after each ESWL for radioopac and radiolucent stones respectively to evaluate treatment efficacy. The patients were categorized into a stone free (SF) or residual stone (RS). Patients with no calcifications or having insignificant stone fragments less than 4 mm at 4 weeks were defined as SF, whereas remaining fragments 4 mm or greater put the patient into the RS group.
Post-treatment stone composition was recorded per patient based on infrared spectroscopic analysis for retrieved fragments.
The demographic characteristics for each patient were obtained from clinical records. Patient age, sex, body mass index (BMI), stone diameter, location, HU density and stone composition were evaluated to predict treatment outcome after ESWL. Statistical analysis was performed using SPSS 15.0 with significance level of 0.05. Chi-square and ANOVA tests were performed as appropriate for univariate analysis. Multivariate logistic regression was analyzed if the parameters present significant statistical difference. Pearson correlation tests were used to determine the correlation between stone density and the number of shock waves needed until complete stone fragmentation.

RESULTS

The 68 patients included 44 males and 24 females. The overall mean age was 42.02 years, the mean BMI 27.3 kg/m^2 and the mean stone size was 13.8 mm. A total of 46 stones (46.65%) were located in the kidney and 22 in the ureter (32.35%). At 3 months of follow-up, 49 patients (70%) were SF and 19 (28%) were RS.
According to univariate analyses, age, sex, gender, BMI, stone size and location were not significant predictors of SF. The stone density range was 302-1455 HU. Successfully treated patients had a significantly lower mean stone density than those with treatment failure (713.32± 253.12 HU versus1178.91± 287.334 HU, respectively; $p < 0,001$) (table). Multivariate logistical regression analysis revealed that stone density on NCCT was an independent predictor of SF outcome. For every 100 HU increase in stone density patients treated with ESWL had significantly lower odds of becoming stone free (OR 0.75, 95% confidence interval [CI] 0.854–0.923, $p = 0.01$).

Tableau 1: Univariate analysis for categorical variables predicting outcome of disintegration by ESWL

Variable	SF	RS	P Value
Age ± SD (Yr)	44.81 (16.76)	44.32 (17.55)	0.32
Gender (n)			0.23
Male	30 (68)	14 (32)	
Female	19 (79)	5 (21)	
BMI ± SD (kg/m2)	25.60 ± 3.3	25.62 ± 2.9	0.72
Location (n)			0.15
Kidney	35 (76)	11 (24)	
Proximal Ureter	14 (63.3)	8 (36.4)	
Stone size (mm)			0.21
≤ 10	15 (79)	4 (21)	
10-20	34 (69)	15 (31)	
Mean stone density ± SD (HU)	713.32 ± 253.126	1178.91 ± 287.334	< 0.001
Stone density threshold (HU)			
< 500	5 (100)	0	0.008
500-1000	15 (83)	3 (17)	
> 1000	5 (38)	8 (62)	

The stone density threshold that best distinguished between the outcome groups was 1000 HU. Stones < 1000 HU were more likely to be treated successfully with ESWL than were stones ≥ 1000 HU (83% versus 38%, respectively; $p = 0,008$). According to multivariate analysis, Stones ≥ 1000 HU were 7.1 times more likely to be treated successfully with ESWL than were stones < 1000 HU (OR 7.1, 95% confidence interval [CI] 2.521–16.812, $p = 0.013$). There was a significant correlation between mean stone density and the number of shock wave needed for stone disintegration (r = 0.74) (Figure 1). Of the 68 patients, stone composition results are available on 62 (91.2%); 46 (74.2%), 11 (17. 75%) and 5 (8.05%) stones were primarily composed of calcium oxalate, struvite and uric acid respectively. Of the 46 calcium oxalate stones, 35 (76.08%) and 11 (23.91%) were monohydrate and dihydrate, respectively. The calcium oxalate monohydrate stones had the lower SF rate following ESWL. The 5 patients with uric acid stones were SF.

The HU values for different types of stones are shown in figure 2. The lowest mean of measured values was related to uric acid stones and the highest to calcium oxalate dihydrate stones. HU values of calcium oxalate stones were significantly different from those of uric acid stones. There was no significant difference in HU values of calcium oxalate monohydrate and dihydrate stones.

Figure 1 : Correlation between mean stone density and the mean number of shock wave needed for stone disintegration (r = 0.74).

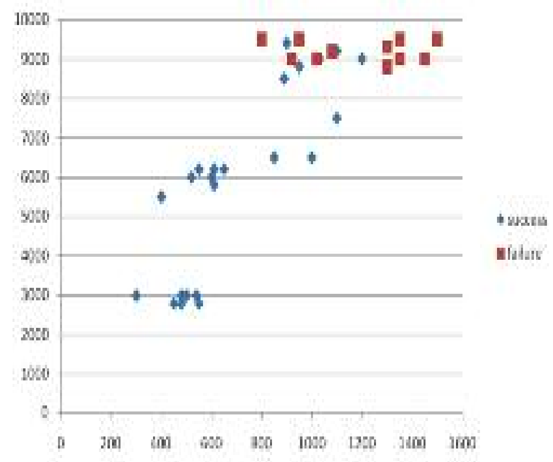
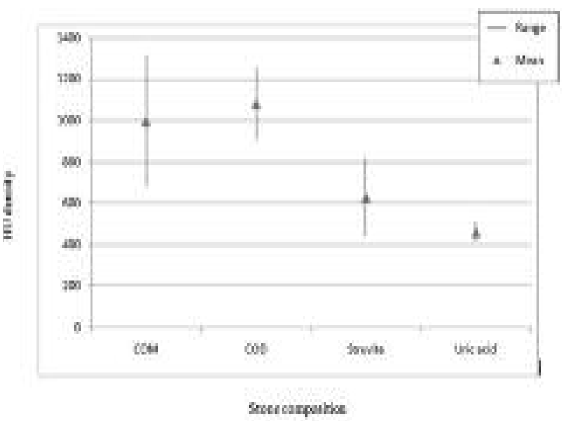


Figure 2 : HU density and stone composition



COM: calcium oxalate monohydrate; COD: calcium oxalate dihydrate.

DISCUSSION

ESWL has radically changed treatment of stone disease and appears to be the first option of the majority of patients because of its ease of use, non invasive nature and high efficacy in treating upper urinary tract stones. (2-3)

ESWL failure may result in unnecessary exposure of the renal parenchyma to shock waves, delay a successful outcome, necessitate additional therapy and augment urinary stones related costs to the individual and health care system (1-4). Therefore there is a clear need to develop a predictive tool for the successful lithotripsy of upper urinary tract stones. Stone density on NCCT < 1000 HU was a significant predictive factor for success of disintegration after ESWL in our study.

A number of factors influencing stone clearance have been identified. These include stone size, location and composition, patient related-factors (age, BMI), the type of lithotripter and its properties (shock wave number, shock wave energy) and the pelvicaliceal anatomy (5-6-7-8). According to our results, age, sex and BMI did not affect ESWL outcome, which is matching with the findings of some authors (9-10). Other authors, however, found that BMI, as well as age were significant factors for stone clearance (4-5-7-8).

NCCT is the preferred imaging modality for the workup of patients with renal colic. It provides precise information about the stone size and location, the decision of ESWL procedure is determined mainly by these parameters. New predictors of ESWL success are being identified with data provided by NCCT. Stone Hounsfield density (HD) and average skin-to-stone distance (SSD) have been suggested as markers predicting ESWL success (1-4-5-7-8-11-12).

A correlation between stone HD and stone fragility was demonstrated. Several clinical studies have verified that ESWL failure is associated with greater stone attenuation (1-4-5-7-11). As the HD of calcium stones increases, a greater number of shock waves are needed for fragmentation (13). In our study CT was performed in 36 patients, and, as expected, stone clearance did correlate with stone HD (*p* < 0,001). There was a correlation between mean stone HD and the number of shock wave needed for stone disintegration. Several investigators have shown that ESWL is more likely to fail for patients with renal calculi > 750-1000 HU and these patients should be considered for other treatment modalities (1-11-14). In the present study, the stone density threshold that best distinguished stones likely to fail ESWL was 1000 HU.

Examination of stone composition in recurrent stone formers can be a predictive factor of ESWL, leading to alternative treatments for hard-to-break stones. In general, stone composed of uric acid are broken easily by shock waves, whereas stones of calcium oxalate monohydrate, brushite (calcium phosphate), or cystine are particularly resistant to ESWL.

Knowing stone composition before treatment is difficult and may not be sufficient to allow prediction of the response to the ESWL. Many groups correlated attenuation on CT with stone composition (5-15-16). They noted that it is possible to distinguish uric acid from calcium based stones but not easy to discern between calcium based stone types. In the present study, significant correlation between HU density and stone composition was noted. However, there was no significant difference in HU values of calcium oxalate monohydrate and dihydrate stones. Future advances in imaging modalities should provide an improved preoperative characterization of stone composition.

The potential weaknesses of this study included its retrospective design, the fact of not performing pretreatment scan for all the patients and the absence of multivariate analysis.

CONCLUSION

The results of the present study have objectived that stone Hounsfield density, measured on NCCT, is important predictor of ESWL outcome. Stone composition determined by infrared spectroscopic analysis is difficult to perform before treatment; however, correlation between stone composition and stone Hounsfield density can be helpful to predict ESWL success.

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