

PREDICTIVE FACTORS OF POST EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY COMPLICATION EVENTS

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ABSTRACT

Objective: To know if pre-morbid factors such as maximum power, maximum frequency, repeated extracorporeal shock wave lithotripsy (ESWL), age, hypertension, diabetic, nutrition, blood coagulation disorders, kidney function disorders, pain perception, stone burden, and stone location, can be used to predict ESWL complication. **Material & methods:** This study is done retrospectively. Analysis was done on 50 patients undergoing ESWL between July 2014 to December 2015. Free variables which evaluated were maximum power, maximum frequency, repeated ESWL, age, hypertension, diabetic, nutrition, blood coagulation disorders, kidney function disorders, pain perception, stone burden, and stone location. Dependent variable which evaluated was steinstrasse event, post ESWL fever, post-ESWL renal colic, post-ESWL hematuria. Age variable were distributed normally and done bivariate analysis by student T-test. Others were abnormally distributed and analyzed univariately by Mann U Whitney. **Results:** During study period, 50 patients were collected. Among them, 60% were men and 40% were women. Mean age of patients undergo ESWL were 50.9 ± 12.7 years. Mean stone size that undergo ESWL were $172.7 \pm 277.8 \text{ mm}^2$. Patients with hypertension before ESWL were 9 patients. Stones were mostly located on kidney pelvis (29 patients), inferior calyx (11 patients), superior calyx (5 patients), middle calyx (4 patients), and 1 patients has staghorn stone. After ESWL, none of the patients complaining severe pain, 35 patient complaining mild pain, and 15 patient complaining moderate pain. Repeated ESWL done in 16 patients (32%). Post-ESWL complication such as hematuria happened on 12 patients, steinstrasse on 1 patient, and colic on 6 patients. None of patients complaining fever. Repeated ESWL happened on 32% patients and have complication risk of hematuria ($p=0.043$). Hypertension is significantly effecting on hematuria event after ESWL ($p=0.015$). **Conclusion:** Hypertension and repeated ESWL can be used as predicting factor of hematuria complication.

Keywords: Extracorporeal Shockwave Lithotripsy, post ESWL complication.

ABSTRAK

Tujuan: Untuk mengetahui jika faktor pre-morbid seperti tenaga maksimal, frekuensi maksimal, extracorporeal shock wave lithotripsy (ESWL) ulang, usia, hipertensi, diabetes, nutrisi, gangguan pengentalan darah, gangguan fungsi ginjal, persepsi nyeri, berat batu dan lokasi batu, dapat digunakan untuk memprediksi komplikasi ESWL. **Bahan & cara:** Penelitian ini dilakukan secara retrospektif. Analisa dilakukan pada 50 pasien yang menjalani ESWL antara bulan Juli 2014 sampai Desember 2015. Variabel bebas mengevaluasi tenaga maksimal, frekuensi maksimal, ESWL ulang, usia, hipertensi, diabetes, nutrisi, gangguan pengentalan darah, gangguan fungsi ginjal, persepsi nyeri, berat batu dan lokasi batu. Variabel gantung mengevaluasi kejadian steinstrasse, demam post-ESWL, nyeri ginjal post-ESWL, hematuria post-ESWL. Usia berdistribusi normal dan dilakukan analisa bivariat menggunakan tes T-student. yang lain berdistribusi abnormal dan dianalisa secara univariasi menggunakan Mann U Whitney. **Hasil:** Selama penelitian, 50 pasien dikumpulkan. Diantaranya 60% laki-laki dan 40% wanita. Rerata usia pasien yang menjalani ESWL adalah 50.9 ± 12.7 tahun. Rerata ukuran batu ESWL adalah $172.7 \pm 277.8 \text{ mm}^2$. Pasien dengan hipertensi sebelum ESWL adalah 9 pasien. Batu ginjal lebih banyak berada di pelvis ginjal (29 pasien), kaliks inferior (11 pasien), kaliks superior (5 pasien), kaliks middle (4 pasien), dan 1 pasien dengan batu staghorn. Setelah ESWL, tidak ada pasien yang mengeluh nyeri hebat, 35 pasien mengeluhkan nyeri ringan, dan 15 pasien mengeluhkan nyeri sedang. ESWL ulang dilakukan pada 16 pasien (32%). Komplikasi post-ESWL seperti hematuria terjadi pada 12 pasien, steinstrasse pada 1 pasien, dan kolik pada 6 pasien. Tidak ada pasien yang mengeluhkan demam. ESWL ulang terjadi pada 32% pasien dan memiliki risiko komplikasi hematuria ($p=0.043$). Hipertensi secara signifikan mempengaruhi kejadian hematuria setelah ESWL ($p=0.015$). **Simpulan:** Hipertensi dan ESWL ulang dapat digunakan sebagai faktor prediksi komplikasi hematuria.

Kata kunci: Extracorporeal Shockwave Lithotripsy, komplikasi post-ESWL.

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INTRODUCTION

Extracorporeal Shock Wave Lithotripsy (ESWL) firstly used on November 1984 at St. Martin Hospital London. ESWL breaks stones inside kidney by using focused shock wave which then minimize the number of open surgery.¹

In an electrohydrolic type shocked wave, a round-shape wave generated by splash under water. This generator benefit is its effectivity in breaking kidney stones,² but then the fluctuation pressure from wave to wave and electrodes age is relatively short.³

Precise stone location related to the ESWL success. Fluoroscopy is a method to find radio-opaque stones in urinary tract, while radio-lucent stones need contrast injection. Fluoroscopy is done by using C-arm, it can spin longitudinally or on its plane then create two intersected planes. Stone location can be precisely known in three dimensions.⁴

Stones fragmentation mechanism by the shocked wave is not fully known, but there are two mechanism that allegedly acted, which are mechanic pressures produced by the shocked wave itself directly or indirectly by the breakage of cavity bubbles. This event can happen pararely or separately at stones surface or inside.

The main purpose of ESWL is to break stones and clear up fragments asymptotically. But then, this procedure is not always fully succeed because the fragmentations are not always complete, with significant size of residual fragments, and ureter obstruction by steinstrasse that leads to urine obstruction.

Success probability of ESWL related to stone volume. For less than 2cm stones, success rate of "stone free" reported as 66-99%, which fell to 45-70% for 2-3cm sized stones, and less for staghorn stones.^{4,5}

OBJECTIVE

This study aim is to know if pre-morbid factors can be used to predict ESWL complication.

MATERIAL & METHOD

This is a retrospective study. Patients in RSUP Dr. Sardjito who undergo ESWL include in this study. Free variables in this study are stone burden, stone number (single or multiple), stone location (pyelum, staghorn, and calix), patients age,

body mass index, blood pressure, kidney function, pain perception based on visual analog, maximum power of shocked wave, and maximum wave amplitude. While dependent variables in this study are steinstrasse event, fever that need to be hospitalized post ESWL, colic post ESWL, and haematuria post ESWL. Age variable were distributed normally and done bivariate analysis by student T-test. Others were abnormally distributed and analyzed univariately by Mann U Whitney.

RESULTS

Based on the data, the average age of the patients who underwent ESWL was 50.9 ± 12.7 years. The youngest patient was 21 years old, the oldest 78 years. The mean stone size do ESWL is $172.7 \pm 277.8 \text{ mm}^2$, the largest stone burden is 1840 mm^2 and the smallest is 15 mm^2 . As many as 60% of patients were male, 40% female patients. Patients suffering from hypertension before ESWL is 9 patients. Based on body mass index 64% is normal, 15 patients have excess weight. There are 5 patients had a number of blood creatinine $>2 \text{ mg/dL}$. Most locations in pyelum kidney stones (29 patients), 11 patients in the inferior Calix. 5 patients in Calix superior, 4 patients in Calix media, and 1 patient had a staghorn stones. Post ESWL no patient had complained of severe pain, 35 patients complained of mild pain and 15 others complained of moderate pain. A total of 35 patients received a maximum frequency of 90 times/minute during ESWL, the other with a frequency of 60 times/min. 38 patients were given a maximum power of 20, while 12 other patients with the power of <20 . ESWL re-performed in 16 patients, or 32%. Complications after ESWL in the form of hematuria many as 12 patients, 1 patient colic and steinstrasse 6 patients. No patient complained of fever.

Table 1. ESWL Complication.

Complication		Number (frequency %)
Hematuria	Yes	12 (24)
	No	38 (76)
Steinstrasse	Yes	1 (2)
	No	49 (98)
Colic	Yes	6 (12)
	No	44 (88)
Fever	Yes	0 (0)
	No	50 (100)

Table 2. Patient characteristic variables.

Variables		Number of Patients (Frequency)	Mean
Age			50.9 + 12.7 y.o
Stone burden			172.7 + 277.8 mm ²
Sex	Male	30 (60)	
	Female	20 (40)	
Hypertension	Yes	9 (18)	
	No	41 (82)	
Body Mass Index	<18.5	1 (2)	
	18.5-24.99	32 (64)	
	25-29.99	15 (30)	
	30-34.99	2 (4)	
Kidney Insufficiency	Yes	5 (10)	
	No	45 (90)	
Stone Location	Pyelum	29 (58)	
	Staghorn	1 (2)	
	Superior Calix	5 (10)	
	Middle Calix	4 (8)	
	Inferior Calix	11 (22)	
Pain Perception (VAS)	Mild	35 (70)	
	Moderate	15 (30)	
	Heavy	0 (0)	
Maximum Frequency	60	15 (30)	
	90	35 (70)	
ESWL number	1	34 (68)	
	>1	16 (32)	
Maximum Power	<20	12 (24)	
	20	38 (76)	
Blood Sugar Level (non-fasting)	<200	31 (62)	
	>200	2 (4)	

Table 3. Relation between variables and post ESWL complication.

Variable	Mean	P			Test
		Hematuria	Colic	Steinstrasse	
Age	50.9 + 12.7 y.o	0.698	0.201	0.753	T-test
Stone Burden	172.7 + 277.8 mm ²	0.131	0.227	0.349	Mann U Whitney
Sex		0.228	0.414	0.218	Mann U Whitney
Hypertension		0.015	0.639	0.929	Mann U Whitney
Body Mass Index		0.618	0.511	0.972	Mann U Whitney
Renal Insufficiency		0.190	0.739	0.389	Mann U Whitney
Stone Location		0.702	0.559	0.920	Mann U Whitney
Pain Perception (VAS)		0.668	0.127	0.452	Mann U Whitney
Maximum Frequency		0.668	0.513	0.851	Mann U Whitney
Maximum Power		0.951	0.577	0.496	Mann U Whitney
Number of ESWL		0.043	0.085	0.587	Mann U Whitney
Non-fasting Blood Glucose Level		0.438	0.439	0.461	Mann U Whitney

DISCUSSION

Main purpose of ESWL is to disintegrate stone and to release stone fragments without complaints. Some factors can be succeed factors, such as stone composition, size, location, number of stones, power, and frequency of shocked wave. Post ESWL complications are including subcapsular hematoma (0.2%), fever > 38.5C (0.5%), steinstrasse (4.4%).⁶

From recent studies, patient age divided four group. First group is less than 19 y.o, second group between 20 to 39 y.o, third group between 40 to 59 y.o, and the last group is more than 60 y.o. The most common group undergo ESWL is 40 to 59 y.o. Stone free rate on patients less than 19 y.o is 93%. Most residual stone fragments is on more than 60 y.o group, which is 43%. Other complication is not mentioned.⁷ In our study, the youngest age is 21 and the oldest is 78 y.o. Mean age is 50 y.o. No statistically significant relation between age and hematuria ($p=0.689$), steinstrasse ($p=0.753$), and colic ($p=0.201$).

Mean stone burden rate is $346 \pm 141 \text{ mm}^2$ with the smallest size is 100 mm^2 and the biggest size is 900 mm^2 .⁶ As much as 5% patients experience subcapsular hematoma, fever, and steinstrasse. Patients with stone burden < 400 mm^2 have stone free rate of 82%, and stone burden > 400 mm^2 have stone free rate of 61.4% ($p<0.001$).⁸ In our study, mean size of stone undergo ESWL is $172.7 + 277.8 \text{ mm}^2$. Complication such as hematuria ($p=0.131$), steinstrasse ($p=0.349$), and colic ($p=0.227$) have no statistically significant relation with stone burden.

A study on 3023 patients undergo ESWL. Among them, 2207 patients are male, and 854 patients are female. Those patients are diagnosed by upper urinary tract infection.⁷ Stone free rate on male patients is 65% with 775 of them has residual stone fragment, while stone free rate on female patients is 66% with 34% of them has residual stone. No other complication mentioned in this study.² In our study, complications such as hematuria found in 9 male and 3 female patients, steinstrasse in 1 male, and colic in 5 male and 1 female patients. No statistically significant relation between sex and hematuria ($p=0.228$), steinstrasse ($p=0.414$), nor colic ($p=0.218$).

A study on 160 patients with 4mm or less residual stones after ESWL found complaints on 43% of them and need more intervention.⁹ A study found stone free rate on stone burden > 400 mm^2 are

81%, 76%, 71%, and 50% on stones located in pyelum, upper calix, lower calix, and proximal ureter.¹⁰ Minimal complications found, such as petechiae at the shocked wave entry site and hematuria post ESWL. While other complication such as kidney hematoma, acute pyelonephritis, perirenalabcess, and steinstrasse found in 34 patients. In our study, stone location has no statistically relation with hematuria ($p=0.702$), colic ($p=0.920$), nor steinstrasse ($p=0.559$).

The number of re-ESWL are 13%, 12%, 9%, and 10% for each stone at pyelum, upper calix, middle calix, and inferior calix, and 15%, 22%, and 13% for each stone at proximal ureter, medial ureter, and distal ureter. Re-ESWL on medial ureter stone are the most common.⁵ In our study, re-ESWL was done in 32% patients and have complication risk of hematuria ($p=0.043$). Hematuria found on the first day after ESWL and relieve without hospitalized.

On patients with hypertension, anatomical structure of the kidney changed. In size, it become smaller. Fine granular seen and tighter than usual. No striking color found, but usually shows vein congestion. Firm consistency, and when it cut, more resistance can be found. Cortex and medulla border become unclear. Large artery at hilum become thinner. Kidney capsule looks clearer and harder to exfoliate from the surface.¹⁰

On microscopic examination, interlobar and archiform arteries become larger and shows wall hypertrophy and lumen dilatation. This hypertrophy limited in most middle layer. Inner layer only shows intermediate tissue thickening with some degenerative inner layer. Adventitia seldomly changes. Lobular artery which thickened and intricate shows different proliferation from inner layer connective tissue and substitution of muscle fibers middle layer by fibrous tissue and basic substance. Reduplication of inner elastic layer also found. But the most prominent change and constant in small arterioles which leads to glomeruli is hyaline swelling from basal membrane and fat sediment. Lumen might be very tight, as the effect of this change. In a longer lesion, the whole wall seems containing hyaline, preventing not only from contraction but also wall relaxation.¹⁰

By those changes found in patients with hypertension before ESWL, might influence complication after ESWL. Acute kidney damage after ESWL can leads to severe injury on nephrons, microvasculars, and interstitials.⁴ Kidney complication can be divided into early complication

on kidney structure that cause hematuria and hematoma formation, and also late complication that affect kidney function that leads to systemic hypertension. Histopathological examination on man and animal kidney show damage on artery, vein, and glomerular capillary endothels right after ESWL. Arching veins have very thick wall and fragile to wave, thus it related to hematuria and hematoma.¹⁰ In our study, hypertension has significant relation to hematuria post ESWL ($p=0.015$), but it heals spontaneously without hospitalization. Mostly, hematuria is the most common complication after ESWL, because of the direct effect from the procedure on kidney tissue and heals spontaneously in couple of days.¹¹

ESWL is the most effective and cost efficient on obese patients with pyelum stone around 6 to 20 mm.¹² Success rate is 87%. Addition on distance from skin surface to stones does not make it success rate lower. Surface area, body side, number of stone, and congenital kidney anomaly are the most important prognosis factors affecting succeed of kidney stone around 20-30 mm after ESWL. Complications post ESWL are subcapsular hematoma 0.2%, fever (temp >38.5 C) 0.5%, and steinstrasse 4.4%.⁶ Body mass index, in our study has no relation to hematuria, colic, nor steinstrasse.

Even though the effect of shocked wave frequency to therapy success has not been evaluated widely, an in vitro study shows that reduction of frequency gain fragmentation probability.¹³ Lithotripsy frequency of shocked wave has significant independent effect to success rate of ESWL. Reduction of shocked wave frequency gain success rate in several ESWL.¹⁴ Frequency and wave power has no significant relation on ESWL in our study.

After ESWL, small complication including renal colic needs analgetic (35.3%) and fever 38.5°C or more (3.6%).⁷ In our study, pain perception during ESWL was around mild to moderate VAS score. No patient complaining colic pain that need to be hospitalized. Pain experienced by patients have no significant meaning to complication post ESWL.

Patients diagnosed by stone might related to kidney dysfunction. Kidney insufficiency etiology on patient with nephrolithiasis is multifactorial, such as kidney obstruction, urinary tract infection, and other disease.¹⁴ A study show 16 patients diagnosed kidney insufficiency before ESWL, but no significant difference compared to control group.¹⁵ Complication mentioned in this study including pain, ureter obstruction or edema, sepsis, steinstrasse, fever, hematuria, and abscess. In our study, 5 patients have creatinine serum >1.5 mg/dL. Patients with kidney insufficiency have no hematuria, steinstrasse, nor colic after ESWL.

Since 1950, kidney dysfunction admitted as one of common complication of diabetes mellitus (DM). DM take responsibility around 30-40% of all chronic kidney failure case in US. Three histological changes found in glomerulus of a nephropathy diabetic patients. First, mesangial expansion directly caused by hyperglycemia, might be by elevated matrix production or matrix protein glycation. Second, thickening of glomerular base membrane (GBM). Third, sclerotic glomerular caused by intraglomerular hypertension (by dilatation of kidney afferent arteries or ischemic injury which caused by hialin that leads to constriction of veins supplying glomerulies).¹⁶ A study showed that repeated shocked wave usage for successful stone fragmentation can sometimes induct acute injury on kidney tissue and surrounding structures, which are pancreas, colon, liver, spleen, pleura, and great artery.¹⁷ A study on 630 patients, with mean age of 48.5 y.o, undergo ESWL with HM-3 lithotripter media in 1985. As much as 8 patients were diagnosed diabetes before ESWL. Complication after ESWL were pain (8 patients), steinstrasse (6 patients), hematuria (2 patients), and fever (2 patients). Diabetes diagnosed event post ESWL related to number of shoot. In our study, 2 patients with non fast in blood glucose >200 mg/dL complaint hematuria. No significant relation between glucose level with hematuria ($p=0.438$), steinstrasse ($p=0.439$), nor colic ($p=0.461$).

CONCLUSION

From analyzed data and discussion of this study, we conclude that hypertension and re-ESWL can be used as predicting factor of hematuria complication.

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