

Innovations

Statistical Analysis to Study the Effectiveness of Treatment Methods for Kidney Stones

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Abstract

Background– In therapeutic areas – the treatment methods for kidney stones have been developed over the years, providing with more than one option to treat the kidney stones. The success rates of the same have been compared and statistically tested to understand the effectiveness of each method and draw conclusions about choosing the best. **Objective** –This study aims at comparing different methods of treating Kidney Stones and establishing which is the most successful. **Methodology and Data** – In this study, data published in 1986 in “The British Medical Journal” has been worked upon. Of the 1052 renal calculi patients, 350 received open surgery, 350 underwent percutaneous, nephrolithotomy, 328 underwent extracorporeal shockwave lithotripsy (ESWL), and 24 underwent both ESWL and percutaneous nephrolithotomy. It was considered a success by a treatment if it could either remove the stones or reduce them to less than 2mm after three months. The same data has been analyzed using descriptive statistics and Chi-square test of independence using MS Excel. **Results and Discussion** – Analysis shows that there exists a significant association between success in treatment and type of treatment, and also it has been observed between success and size of kidney stone. The modes of total cases and success cases have been compared to see that they vary for different kidney stone size groups, and for the overall case.

Keywords: Efficiency, Kidney stone, treatment, Data analysis, chi-square.

Introduction

Kidney stone disease is acrysallopathy where a solid piece of material (kidney stone) develops in the urinary tract. Kidney stones typically form in the kidney and

leave the body in the urine stream. A small stone may pass without causing symptoms.[2] If a stone grows to more than 5 millimeters (0.2 inches), it can cause blockage of the ureter, resulting in sharp and severe pain in the lower back or abdomen.[3] A stone may also result in blood in the urine, vomiting, or painful urination. About half of people who have had a kidney stone will have another within ten years.[2] Urolithiasis is the medical term used to describe stones occurring in the urinary tract. Other frequently used terms are urinary tract stone disease and nephrolithiasis. Terms that describe the location of the stone in the urinary tract are sometimes used. For example, a ureteral stone—or ureterolithiasis—is a kidney stone found in the ureter. [4]

Urolithiasis affects 5-15% of the population worldwide. [3] A person with a large enough stone, or one that blocks urine flow and causes great pain, may need more urgent treatment, among which the one involved in this study are:

- Open surgery- The surgical treatment of urolithiasis has changed significantly over the past 30 years. Previously, most patients requiring stone removal underwent open surgery.[5] All renal and ureteric calculi were treated by-
 - nephrolithotomy (removal of a stone from the kidney)/pyelolithotomy
 - pyelolithotomy (removal of stone within the renal pelvis)
 - ureterolithotomy (removal of a stone from the ureter)
- Percutaneous nephrolithotomy (PCNL)- A minimally-invasive procedure to remove stones from the kidney that consists of the urologist making a ½ inch incision in the patient’s back, through which is placed a hollow tube that provides access to the inside part of the kidney that contains the stone(s). Using a rigid metal telescope, the stones are removed directly or broken into fragments which are removed.[6] [7]
- Extracorporeal Shock Wave Lithotripsy (ESWL)- The method consists of general anesthesia being given to the patient by an anesthesiologist and, high energy shock waves transmitted through water and directed at the kidneys to break the stones into smaller pieces. The small pieces of kidney stones can now pass easily through the urinary tract.[8]
- Percutaneous nephrolithotomy and ESWL combined- With development of new treatment methods for a medical condition over the years, certain aspects need to be studied to establish the effectiveness of the same. For this purpose, data published in The British Medical Journal (1986) in the article “Comparison of Treatment of Renal Calculi by open surgery, percutaneous nephrolithotomy, and extracorporeal shockwave lithotripsy” (CR Charig et al.) [1], has been analyzed with the following objectives –

- 1) Testing the independence of success in treatment and use of a specific treatment method using Chi-square test
- 2) To test whether the success in a treatment method is independent of factors such as size of Kidney stones.

Data and methodology

The dataset used in this project is based on the original medical paper published in The British Medical Journal in 1986, “Comparison of Treatment of Renal Calculi by open surgery, percutaneous nephrolithotomy, and extracorporeal shockwave lithotripsy” (CR Charig et al.)[1], where effectiveness of two types of kidney removal treatment methods was compared.

The following table consists of data about the kidney stone patients undergoing different treatment methods. The patients are also divided into two groups based on the size of kidney stone, as – Group 1 < 2cm (G1) and Group 2 >= 2cm (G2).

Treatment Method	< 2 cm (G1)	>= 2 cm (G2)	Total	Mean age	Male (%)	Female (%)
Nephrolithotomy/Pyelolithotomy	13	218	231	45	45	55
Pyelolithotomy	31	45	76	47	51	49
Ureterolithotomy	43	0	43	46	69	31
All open procedures	87	263	350	46	55	45
Percutaneous nephrolithotomy	270	80	350	52	68	32
ESWL	204	124	328	48	70	30
Percutaneous nephrolithotomy and ESWL	0	24	24	48	70	30

Table 1

The successes in various treatment methods are tabulated in the following table as number of successful cases with respect to each treatment method and group (based on size of kidney stone)

Treatment Method	< 2 cm (G1)	>= 2 cm (G2)	Overall successes
Nephrolithotomy/Pyelolithotomy	12	154	166
Pyelolithotomy	26	38	64
Ureterolithotomy	43	0	43
All open procedures	81	192	273
Percutaneous nephrolithotomy	234	55	289
ESWL	200	101	301

Percutaneous nephrolithotomy and ESWL	0	15	15
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Table 2

Statistical Analysis

Descriptive Statistics is used to analyze the dataset. The data is divided and organized in tabular form to represent details about total and successful cases for each method in all, the same for each group of kidney stone size, and the proportion of male and female population undergoing the treatment.

The graphs formed and central tendencies thus obtained are utilized to draw conclusions about the treatment methods and their effectiveness.

A dependence between the success and treatment method used is tested by using chi squared test of independence. It is also tested whether there exists a significant dependence of success of a treatment on factors such as type of kidney stone.

Results

Chi-square Analysis

1. Hypothesis:

H₀: Treatment method and Success in treatment are independent.

H_a: Treatment method and Success in treatment are not independent.

Treatment Method	Successes	Unsuccessful cases	Total
All open procedures	273	77	350
Percutaneous nephrolithotomy	289	61	350
ESWL	301	27	328
Percutaneous nephrolithotomy and ESWL	15	9	24
Total	878	174	1052

Table 3.1 - Contingency Table with Observed Frequencies

Treatment Method	Successes	Unsuccessful cases	Total
All open procedures	292.1102662	57.88973384	350
Percutaneous nephrolithotomy	292.1102662	57.88973384	350
ESWL	273.7490494	54.25095057	328
Percutaneous nephrolithotomy and ESWL	20.03041825	3.969581749	24
Total	878	174	1052

Table 3.2 - Contingency Table with Expected Frequencies

Observed frequency (O_i)	Expected frequency (E_i)	χ^2
273	292.1102662	1.250220602
289	292.1102662	0.033116794
301	273.7490494	2.712755747
15	20.03041825	1.263333968
77	57.88973384	6.308584415
61	57.88973384	0.167106583
27	54.25095057	13.68850314
9	3.969581749	6.374754163

Table 3.3

Calculated $\chi^2 = 31.79837541$
 Tabulated $\chi^2 = 7.814727903$

Since calculated test statistic is greater than the tabulated test statistic, null hypothesis is rejected, which implies that the Treatment Method and success in treatment are not independent and there exists a significant association between them.

2. Hypothesis:

H_0 : Type of Open Procedure treatment method and Success in treatment are independent.

H_a : Type of Open Procedure treatment method and Success in treatment are not independent.

Treatment Method	Successes	Unsuccessful cases	Total
Nephrolithotomy/Pyelolithotomy	166	65	231
Pyelolithotomy	64	12	76
Ureterolithotomy	43	0	43
Total	273	77	350

Table 4.1 - Contingency Table with Observed Frequencies

Treatment Method	Successes	Unsuccessful cases	Total
Nephrolithotomy/Pyelolithotomy	180.18	50.82	231
Pyelolithotomy	59.28	16.72	76
Ureterolithotomy	33.54	9.46	43
Total	273	77	350

Table 4.2 - Contingency Table with Expected Frequencies

Observed frequency	Expected frequency	χ^2
166	180.18	1.115952936
64	59.28	0.375816464
43	33.54	2.668205128
65	50.82	3.956560409
12	16.72	1.332440191
0	9.46	9.46

Table 4.3

Calculated $\chi^2 = 18.90897513$

Tabulated $\chi^2 = 5.991464547$

Since calculated test statistic is greater than the tabulated test statistic, null hypothesis is rejected, which implies that the Type of Open Procedure treatment Method and success in treatment are not independent and there exists a significant association between them.

3. Hypothesis:

H₀: Success in a treatment method and size of kidney stone are independent.

H_a: Success in a treatment method and size of kidney stone are not independent.

Treatment Method	< 2 cm (G1)	>= 2 cm (G2)	Total
All open procedures	81	192	273
Percutaneous nephrolithotomy	234	55	289
ESWL	200	101	301
Percutaneous nephrolithotomy and ESWL	0	15	15
Total	515	363	878

Table 5.1 - Contingency Table with Observed frequencies

Treatment Method	< 2 cm (G1)	>= 2 cm (G2)	Total
All open procedures	160.1309795	112.8690205	273
Percutaneous nephrolithotomy	169.5159453	119.4840547	289
ESWL	176.5546697	124.4453303	301
Percutaneous nephrolithotomy and ESWL	8.798405467	6.201594533	15
Total	515	363	878

Table 5.2 - Contingency Table with Expected Frequencies

Observed frequency	Expected frequency	χ^2
81	160.1309795	39.10368834
234	169.5159453	24.52980632
200	176.5546697	3.113389828
0	8.798405467	8.798405467
192	112.8690205	55.47768456
55	119.4840547	34.80124037
101	124.4453303	4.417068213
15	6.201594533	12.48258627

Table 5.3

Calculated $\chi^2 = 182.7238694$

Tabulated $\chi^2 = 7.814727903$

Since calculated test statistic is greater than the tabulated test statistic, null hypothesis is rejected, which implies that the Success in a treatment method and size of kidney stone are not independent and there exists a significant association between them.

4. Hypothesis:

H₀: Success in a type of Open Procedure treatment method and size of kidney stone are independent.

H_a: Success in a type of Open Procedure treatment method and size of kidney stone are not independent.

Treatment Method	< 2 cm (G1)	>= 2 cm (G2)	Total
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Nephrolithotomy/Pyelolithotomy	12	154	166
Pyelolithotomy	26	38	64
Ureterolithotomy	43	0	43
Total	81	192	273

Table 6.1 - Contingency Table with Observed frequencies

Treatment Method	< 2 cm (G1)	>= 2 cm (G2)	Total
Nephrolithotomy/Pyelolithotomy	49.25274725	116.7472527	166
Pyelolithotomy	18.98901099	45.01098901	64
Ureterolithotomy	12.75824176	30.24175824	43
Total	81	192	273

Table 6.2 - Contingency Table with Expected frequencies

Observed frequency	Expected frequency	χ^2
12	49.25274725	28.17644203
26	18.98901099	2.588548026
43	12.75824176	71.68416768
154	116.7472527	11.88693648
38	45.01098901	1.092043698
0	30.24175824	30.24175824

Table 6.3

Calculated $\chi^2 = 145.6698962$

Tabulated $\chi^2 = 5.991464547$

Since calculated test statistic is greater than the tabulated test statistic, null hypothesis is rejected, which implies that the Success in a type of Open Procedure treatment method and size of kidney stone are not independent and there exists a significant association between them.

Discussion

From the Chi-square analysis it is observed that there exist some significant association between success of a treatment and type of treatment used. As well as, association between the type of Open procedure used and the success of treatment is also observed.

Also the successes and size of kidney stone were found to not be independent, implying there exists some association between the same too.

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