Perioperative Complications and Risk Factors of Percutaneous Nephrolithotomy

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Objective: *To study the risk factors of perioperative complications of PerCutaneous NephroLithotomy (PCNL).*
Material and Method: *The present prospective descriptive study was carried out in the first time operation of 128 PCNL patients after general balanced anesthesia and standard surgical technique. Irrigation fluids were 0.9% NSS (24.1 $\pm$ 16.36 liters) at room temperature. Perioperative complications and risk factors were observed, the results were displayed as adjusted Odds Ratio (OR), 95%CI and p value.*
Results: *Intraoperative complications were hypothermia (56.2%), cardiovascular changes (57.1%) and bleeding. The first two complications statistically significantly related to volume of irrigation fluid > 20 liters (7.4, $p < 0.05$). Postoperative complications were electrolyte changes (but not statistically significant), pleural tear (3 cases), infection and bleeding. Septic shock was found in 4.7% (6/128) and 0.78% (1/128) died. Fever was significantly correlated with postoperative transfusion $\geq$ 1 unit (adjusted OR 4.9, $p < 0.05$). Risk factors of postoperative bleeding were operation time (adjusted OR 4.4, $p < 0.05$), intraoperative transfusion (adjusted OR 10, $p < 0.01$) and postoperative fever (adjusted OR 4.9 $p < 0.01$). Mean was 7.3 $\pm$ 5.22 days and the mode of Length Of Stay after operation (LOS_{PO}) was 5 days. LOS_{PO} was significantly related with postoperative fever > 38.5 ^{o}C (adjusted OR 2.7, $p < 0.05$).*
Conclusion: *Volume of irrigation fluid at room temperature >20 liters significantly increased the rate of intraoperative hypothermia and cardiovascular changes. Infection was the most serious complication of PCNL and increased LOS_{PO}. Antibiotics started at the beginning of the surgery could not always prevent this event.*

Keywords: *Renal stone, Urolithiasis, PCNL, Irrigation fluid, Postoperative length of stay*

J Med Assoc Thai 2006; 89 (6): 826-33
Full text. e-Journal: *http://www.medassocthai.org/journal*

PerCutaneous NephroLithotomy (PCNL) is a minimal invasive surgery for renal calculi that was first reported by Fernstr m and Johannson in 1976[1]. Most urologists believe that this operation is better than open surgery due to decreases the length of stay, less morbidity, less pain and more preserved kidney function[2]. Thailand is in the Afro-Asian stone belt that has a high incidence of urolithiasis[3]. In Siriraj Hospital, PCNL has been the preferred choice for large renal stone removal since 1999. The first two years of PCNL, there were many serious complications causing high morbidity and mortality. By observing from previous operations the authors found that some of these complications were correctable and could be prevented or the severity could be decreased. Therefore, the authors began to study perioperative complications and their risk factors for improving the outcome of PCNL in our hospital and finding ways that might decrease morbidity and mortality rates.

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Material and Method

The authors did a prospective descriptive study from October 2000 to the end of July 2002 to find out the risks that were related to perioperative complication of PCNL patients. The protocol was approved

by the Ethics Committee of Siriraj Hospital, Faculty of Medicine; Mahidol University and informed consent was obtained from the patients. Inclusion criteria were: age > 18 years, first time of PCNL operation and no serious uncorrectable bleeding disorder.

All the patients received prophylactic antibiotics according to the surgeons' choice. They mostly used ceftriaxone 1 gram intravenous before the beginning of standard technique of general balanced anesthesia and operation. The vital signs, percutaneous oxygen saturation, end-tidal CO_2, airway pressure, tympanic membrane temperature, bleeding and volume of irrigation fluid (0.9% NSS in room temperature) were monitored during the operation. Chest X-rays were done in all cases when pleural tears were suspected just after operation. Electrolytes were observed on the first postoperative day. The authors also recorded the volume of blood transfusion during and postoperation, postoperative rising of body temperature, hematocrit and Length Of Stay postoperative before discharge (LOS_{PO}).

Statistical data analysis

Descriptive statistics were presented as mean, Standard Deviation (SD), mode, minimum, maximum or number (%) as appropriate. To assess the association between two categorical variables in a univariable analysis, chi-square test was used along with Odds Ratio (OR) and its 95% Confidence Interval (CI). Multivariable analysis via multiple logistic regression was employed to determine the effect of each independent variable on binary dependent variable after adjusting for the other independent variables. Results were displayed as adjusted OR and 95%CI. Pearson's correlation was used to determine the linear relationship between two normally distributed quantitative variables. All statistical data analyses were performed by using SAS 8.0. A two-sided p-value of ≤ 0.05 was considered statistically significant.

Results

Seventy eight men (60.9%) and fifty women (39.1%) with a mean age of 48.9 $\pm$ 13.54 years old, 12.5% aged > 65 were included in the present study. ASA I was 59.3%, ASA II was 31.3% and ASA III was 9.4%. The mean weight was 58.1 $\pm$ 10.05 kilograms.

Intraoperative period

Duration of surgery was 120 $\pm$ 49 minutes, and 43.8% of the patients had an operation time > 120 minutes. The amount of irrigation fluid during surgery varied from 5 to 97 liters with the mean of 24.1 $\pm$ 16.36 liters and 41.9% of the patients received > 20 liters of irrigation fluid. The average body temperature was 35.1 $\pm$ 0.88 C and 56.2% of the patients had intraoperative body temperature $\leq$ 35.0 C. During the operation 57.1% of the patients had blood pressure changes of more than 20% of the base line. The need for blood transfusion was 16% and maximum transfusion during operation was 2 units in 7.6% of the patients.

Factors associated with intraoperative hypothermia

Intraoperative hypothermia was defined as body temperature $\leq$ 35.0 C. There was no relationship between hypothermia and age, operative time or intraoperative transfusion as shown by both univariable and multivariable analysis ($p > 0.05$). Multiple logistic regression analysis, showed that only the amount of irrigation fluid > 20 liters was a statistically significant factor related to intraoperative hypothermia with adjusted OR of 7.4 (2.13, 25.94 and $p = 0.002$) (Table 1).

Factors associated with intraoperative bleeding and transfusion

Operation time, irrigation fluid seemed to increase the risk of intraoperative bleeding (crude OR > 1 and $p < 0.05$, Table 2). However, multiple logistic regression analysis showed these factors had no statistical significance. Age and intraoperative hypothermia were also not statistically significantly related with intraoperative blood transfusion ($p > 0.05$).

Factors associated with intraoperative blood pressure changes

During operation 68/119 (57.1%) of the patients had blood pressure changes of more than 20% of the base line. There were 33/119 (27.7%) patients who developed hypotension and 35/119 (29.4%) patients who developed hypertension**.** Among these patients, 18/33 and 19/35 had received of more than 20 liters irrigation fluid. From Pearson Chi-Square test showed that the changes in blood pressure were significantly correlated with the amount of irrigation fluid > 20 liters ($p = 0.009$).

Postoperative period

The most serious complication in the postoperative period was sepsis. The mean temperature of the patients was 38.3 $\pm$ 0.96^{0}C and 42.4% of the patients had fever > 38.5^{0}C. Septic shock was found in 6/128 (4.7%) and one patient died 1/128 (0.78%). Mean hematocrit was decreased by 5.4 $\pm$ 3.34% and 20.2% needed

Table 1. Risk factors of intraoperative hypothermia

Variables (n)		Intraoperative hypothermia		Crude OR (95%CI)	Adjusted OR (95% CI)
		>35°C	≤35°C		
Age [yr]	≤65 (103)	29	74	1	1
	>65 (13)	5	8	0.86 (0.55, 1.34), p = 0.442	0.48 (0.13, 1.85), p = 0.287
Operation time [min]	≤120 (62)	21	41	1	1
	>120 (57)	16	41	1.17 (0.93, 1.47), p = 0.185	0.58 (0.19, 1.76), p = 0.339
Irrigation fluid [L]	≤20 (66)	27	39	1	1
	>20 (49)	6	43	1.49 (1.81, 1.86), p = 0.001*	7.42 (2.13, 25.94), p = 0.002*
Intraoperative blood transfusion [unit]	0 (92)	29	63	1	
	≥1 (18)	5	13	1.12 (0.83, 1.50), p = 0.510	0.80 (0.21, 3.07), p = 0.747

* $p < 0.05$

Table 2. Risk factors of intraoperative bleeding

Variables (n)		Intraoperative transfusion (unit)		Crude OR (95% CI)	Adjusted OR (95% CI)
		0	≥1		
Age [yr]	≤65 (104)	87	17	1	1
	>65 (15)	13	2	0.81 (0.20, 3.30), p = 0.766	0.35 (0.10, 2.84), p = 0.310
Operation time [min]	≤120 (67)	61	6	1	1
	>120 (52)	39	13	1.74 (1.18-2.60), p = 0.018*	2.26 (0.60, 8.53), p = 0.230
Irrigation fluid [L]	≤20 (67)	61	6	1	1
	>20 (49)	37	12	1.77 (1.17, 2.67), p = 0.022*	2.43(0.63, 9.54), p = 0.198
Intraoperative hypothermia [°C]	>35 (48)	43	5	1	1
	≤35 (61)	49	12	0.63 (0.29, 1.36), p = 0.186	1.31 (0.39, 4.41), p = 0.662

* $p < 0.05$

blood transfusion. Pleural tear was detected in 3/128 (2.4%) patients and all of them needed chest drainage. Mean was 7.3 ± 5.23 days and mode of the LOS_{PO} was 5 days.

Relationship between amount of irrigation fluid and changes in electrolytes

After 24.1 ± 16.36 liters of 0.9% NSS were used during the operation, there were changes in electrolytes as shown in Table 3. (i.e., mode of changes of sodium, potassium, chloride and bicarbonate were -3, 0, -6 and -3 respectively). When irrigation fluid and changes in electrolytes were dichotomized as irrigation fluid ≤ 20, > 20 liters and changes in electrolytes < 0, ≥ 0, no association was found between irrigation fluid and changes in electrolytes ($p > 0.05$).

Factors associated with postoperative bleeding

Results from multivariable analysis showed the requirement of postoperative blood transfusion statistically significant with operation time, intraoperative transfusion and postoperative fever as adjusted ORs of 4.4, 10 and 4.9 respectively. Volume of irrigating fluid and intraoperative hypothermia seemed to increase the risk of postoperative bleeding but from multivariable analysis the authors found no statistical significance as $p > 0.05$ (Table 4).

Factors associated with postoperative fever

Duration of operation > 120 min, volume of irrigation fluid > 20 liters and postoperative transfusion seemed to increase the risk of postoperative fever. But results from multivariable analysis showed that only postoperative transfusion had statistical significance with postoperative fever as adjusted OR 4.9 (1.6, 14.7) and $p = 0.004$. Age ≥ 65 years, volume of irrigation fluid and intraoperative hypothermia seemed to increase the risk of postoperative fever but there was

Table 3. Electrolyte changes postoperation and correlation with amount of irrigation fluid

Variables (n)		Mean ± SD (mode), [Min, max] meq/l	Variables change (n)	Irrigating fluid (L)		p value
				≤20	>20	
Sodium	Pre (115)	142.7±3.44 (142), [132, 149]				
	Post (107)	141.5±4.29 (144), [127, 151]	< pre op (61)	31	30	0.176
			≥ pre op (42)	27	15	
	Post-Pre (106)	-1.3±4.45 (-3), [-14,11]				
Potassium	Pre (115)	4.1±0.40 (4.1), [3.1, 5.2]				
	Post (107)	4.0±0.50 (4.1), [2.7, 5.7]	< pre op (54)	35	19	0.068
			≥ pre op (49)	23	26	
	Post-Pre (106)	-0.14±0.54 (0), [-1.6, 0.9]				
Chloride	Pre (115)	106.0±3.72 (106), [98, 115]				
	Post (105)	106.4±4.78 (104), [93, 119]	< pre op (42)	22	20	0.384
			≥ pre op (59)	36	23	
	Post-Pre (104)	0.17±4.80 (-6), [-12, 15]				
Bicarbonate	Pre (114)	22.4±3.74 (22), [13, 31]				
	Post (108)	20.2±3.51 (20), [10, 27]	< pre op (65)	33	32	0.138
			≥ pre op (38)	25	13	
	Post-Pre (106)	-2.12±4.06 (-3), [-12, 8]				

Table 4. Risk factors associated with postoperative bleeding

Variables(n)		Postoperative blood transfusion (unit)		Crude OR (95%CI)	Adjusted OR (95%CI)
		0	≥1		
Age [yr]	≤65 (111)	81	30	1	1
	>65 (16)	12	4	0.90 (0.27-3.01), p = 0.864	0.542 (0.32, 3.14), p = 0.494
Operation time [min]	≤120 (71)	58	13	1	1
	>120 (56)	35	21	1.64 (1.13-2.38), p = 0.015*	4.42 (1.24, 15.78), p = 0.022*
Irrigation fluid [L]	≤20 (71)	56	15	1	
	>20 (52)	34	18	1.44 (0.96-2.17), p = 0.095	0.74 (0.19, 2.84), p = 0.668
Intraoperative	≤35.0 (64)	49	15	1	1
hypothermia [^{O}C]	>35.0 (51)	35	16	1.24 (0.81-1.89), p = 0.341	0.34 (0.104, 1.124), p = 0.077
Intraoperative blood	0 (100)	82	18	1	1
transfusion [unit]	≥1 (19)	7	12	5.09 (2.21-11.73), p = 0.000*	9.98 (2.44-40.91), p = 0.001*
Postoperative	≤38.5 (72)	60	12	1	1
fever [^{O}C]	>38.5 (53)	32	21	3.28 (1.43-7.52), p = 0.004*	4.92 (1.63-14.88), p = 0.005*

* $p < 0.05$

no statistical significance ($p > 0.05$, Table 5).

Factors associated with prolonged postoperative LOS

Results from multivariable analysis showed only postoperative fever increased the risk of prolonged LOS_{PO}(adjusted OR = 2.7 and p = 0.027, Table 6). Duration of operation, intraoperative hypothermia, bleeding seemed to increase LOS_{PO} but was not significant (adjusted ORs > 1, p > 0.05).

Discussion

Major intraoperative complications of PCNL in the present study were hypothermia, bleeding and cardiovascular changes. About hypothermia, 56.2% of the patients had tympanic membrane temperature ≤ 35°C. The only risk factor that significantly related to hypothermia in the present study was volume of irrigation fluid > 20 liters. Malhotra SK, et al reported that fluid absorption occurred in 78% of the PCNL patients

Table 5. Risk factors associated with postoperative fever

Variables(n)		Postoperative fever [^{O}C]		Crude OR (95%CI)	Adjusted OR (95%CI)
		≤38.5	>38.5		
Age [yr]	≤65 (109)	62	47	1	1
	>65 (16)	10	6	0.82 (0.32-2.10), p = 0.088	1.10 (0.31, 3.89), p = 0.880
Operation time [min]	≤120 (71)	43	28	1	1
	>120 (54)	29	25	1.17 (0.79-1.75), p = 0.442	0.84 (0.31, 2.29), p = 0.728
Irrigation fluid [L]	≤20 (71)	42	29	1	1
	>20 (50)	26	24	1.18 (0.78-1.81), p = 0.435	1.24 (0.46, 3.38), p = 0.673
Intraoperative	≤35.0 (63)	34	29	1	1
hypothermia [^{O}C]	>35.0 (50)	29	21	0.91 (0.60-1.39), p = 0.668	1.35 (0.56, 3.23), p = 0.501
Intraoperative blood	0 (98)	55	43	1	1
transfusion [unit]	≥1 (19)	11	8	0.94 (0.41-2.17), p = 0.887	0.48 (0.13-1.72), p = 0.257
Postoperative blood	0 (92)	60	32	1	1
transfusion [unit]	≥1 (33)	12	21	2.38 (1.29-4.39), p = 0.004	4.91 (1.64-14.65), p = 0.004*

* $p < 0.05$

Table 6. Risk factors associated with postoperative length of stay (LOS_{PO})

Variables(n)		LOS_{PO} [day]		Crude OR (95%CI)	Adjusted OR (95%CI)
		≤5	>5		
Age [yr]	≤65 (102)	56	46	1	1
	>65 (15)	4	11	3.35 (1-11.22), p = 0.041*	3.69 (0.94, 14.48), p = 0.061
Operation time [min]	≤120 (66)	40	26	1	1
	>120 (51)	20	31	2.38 (1.12-0.04), p = 0.022*	1.87 (0.65, 5.35), p = 0.247
Irrigation fluid [L]	≤20 (66)	35	31	1	1
	>20 (48)	24	24	0.93 (0.61-1.43), p = 0.749	0.419 (0.14, 1.29), p = 0.128
Intraoperative	≤35.0 (59)	30	29	1	1
hypothermia [^{0}C]	>35.0 (48)	25	23	1.05 (0.49-2.25), p = 0.899	1.18 (0.46, 2.97), p = 0.734
Intraoperative blood	0 (98)	54	44	1	1
transfusion [unit]	≥1 (19)	6	13	2.28 (0.93-5.59), p = 0.06	3.37 (0.88, 12.89), p = 0.084
Postoperative	≤38.5 (64)	40	24	1	1
fever[^{O}C]	>38.5 (51)	20	31	1.62 (1.10-.38), p = 0.013*	2.74 (1.12, 6.71), p = 0.027*
Postoperative blood	0 (87)	50	37	1	1
transfusion [unit]	≥1 (30)	10	20	1.57 (1.10,2.23), p = 0.023*	1.67 (0.57, 4.91), p = 0.293

* $p < 0.05$

and 28% had volume absorption more than 1 liter. The study also showed that volume of fluid absorption depended on volume of irrigation fluid, irrigation time and rate of irrigation. Mean of fluid absorption was 696.7 ± 603 (0-1916.2) ml, absorption volumes were over 1 liter when the patients received more than 20 liters[4] of irrigation fluid. In the present study Amplatz' renal sheaths for releasing pressure in the kidneys were used in all cases so there was a decreased risk for absorption of irrigation fluid. Using a high volume of room temperature irrigation fluids could produce heat loss in the presented patients by some intravascular absorption through open injured vein and some from soaking internal organs after leakage into the peri-nephric space. Forced air warming blankets did not reduce hypothermia due to the small area of effective contact with the bodies. Like other studies, the major side effect of hypo-thermia in the presented patients was slow recovery from anesthesia and muscle relaxant. This is especially noteworthy as most of the presented

patients had impaired renal function. Hypothermia might also cause postoperative shivering, cardiovascular complication, wound healing, infection and bleeding[5,6]. Intraoperative bleeding in PCNL was not a big problem. Only 16% (19/119) of the patients needed blood transfusion and the largest amount of intraoperative transfusion was only 2 units (7.6%). The causes of bleeding were direct injury to blood vessels, laceration of the kidney during operation especially with the technique of percutaneous tract creation[7,8], multiple nephrostomy tracts and size of the tract as reported by Kukreja R[7,9]. Injury to blood vessels could occur at anytime so intraoperative bleeding in the presented patients seemed to relate with intraoperative hypothermia, duration of operation and volume of irrigation fluid. This is however not significant ($p > 0.05$, Table 2). During the operation the authors also found cardiovascular changes (more than $\pm$ 20% of the base line) in 57.1% of the patients. Hypertension caused by hypervolemia from irrigation fluid absorption and/or from hormonal changes was found in 29.4%[4,10]. The report of Atici et al[11] showed significant increase in ACTH, renin and aldosterone during surgery of PCNL that might cause an increase in blood pressure.

Postoperative complications were urohemothorax, electrolytes imbalance, bleeding, infection and prolonged length of stay in the hospital. The authors found 3/128 (2.3%) of the patients developed dyspnea in the early postoperative period. All of these patients were suspected pleural tear by the surgeon since intraoperation. The chest drainages were performed successfully without any serious problem. Electrolytes mostly decreased but there was no statistical significance ($p > 0.05$) in the postoperative period and not related to the volume of irrigation fluid. This is the same result as found by K roglu A, et al[2], Atici S, et al[11]and Moorthy[12]. These mechanisms are still not clear, they may be caused by complicated factors result from hormonal changes during operation[11], homeostasis of the body or anything else that should be followed by further study. Postoperative bleeding was not an uncommon complication of PCNL[9,13]. Mean decreasing of the hematocrit was 5.4% $\pm$ 3.341 (mode 6) and the largest drop was 14.4%. There was significant correlation with operative time > 120 min, intraoperative bleeding and fever (Table 4). Bleeding continued from intra operation that was caused by laceration or injury to vessels or parenchyma. The study of Kukreja R, et al showed that factors affecting blood loss during PCNL were nature of nephrostomy tract, operative time, and method of access guidance, method of tract dilatation, multiple tracts, size of tract, renal parenchymal thickening, and diabetes[14]. All but one of the presented patients needed no other interventions. One patient had prolonged postoperative bleeding that needed multiple blood transfusions and ended with embolization of pseudoaneurysm that was caused by high pressure leakage from lacerated artery[13,15]. Fever is one of the most worrisome and serious complications of PCNL because of the high possibility of bacteremia or endotoxemia[16,17]. The source of infection always comes from the stone itself[18]. Most fever developed within 24 hours following the operation although all of the patients had preoperative and postoperative prophylaxis antibiotics. One of the presented patients (0.78%) died from septic shock, DIC and multi organs dysfunction on the second postoperative day. This mortality rate was higher than Viville's report in 1993[18]. There were 42.4% of the presented patients who had a temperature > 38.5°C, compared to 35% in the previous report[19]. This significantly correlated with postoperative blood transfusion (Table 5, adjusted OR 4.9, $p = 0.004$). They are important because the degree of bleeding from PCNL showed more injured renal parenchyma or tear of vessels[20] that increased the risk of bacteremia or endotoxemia. Leakage of infected fluid from the kidney into the retroperitoneum can also be reabsorbed slowly back into circulation and may cause infection in postoperative period[21,22]. Marippan et al in 2005 showed that sensitivity and specificity for predicting Systemic Inflammatory Response Syndrome (SIRS) of bladder, pelvic urine Culture and Sensitivity (C & S) are only 50%, 63% and 36.8%, 87.9% respectively. Sensitivity and specificity for predicting SIRS from stone C & S are 73.7% and 81.8%[23] respectively. They recommend that broad spectrum antibiotics should be given for 1 week as pretreatment in patients who have dilated pelvicaliceal system and stone sizes $\geq$ 20 mm. Septicemia can develop in the patients with preoperative sterile urine as well as these who received prophylactic antibiotic. It is the same as the presented patients. Mode LOS_{PO} in our hospital was 5 days and is similar as the report of Wong's (5.2 days)[24] and Koroglu's (5.1 days)[2]. Hospital stay of PCNL following staghorn stone (Al- Kohlany's study) was 6.4 $\pm$ 4.2 days and is significantly shorter than open surgery[25]. The present report is in line with Wong and Koroglu's report that showed a short stay in the hospital due to the inclusion of all kinds of renal stone and not only staghorn stone. In the present study, postoperative length of stay > 5 days was significantly related to

fever > 38.5°C (adjusted OR = 2.7, p = 0.027, Table 6). Only one patient had a longest postoperative length of stay due to bleeding from pseudoaneurysm following PCNL.

Conclusion

Intraoperative complications of PCNL related to volume of irrigation fluid >20 liters at room temperature were intraoperative hypothermia and cardiovascular changes. Bleeding and infection were also two serious postoperative complications that pre and postoperative antibiotics could not entirely prevent.

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อันตรายและปัจจัยเสริมให้เกิดผลข้างเคียงของการผ่าตัด Percutaneous Nephrolithotomy

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วัตถุประสงค์*: เพื่อศึกษาปัจจัยส่งเสริมให้เกิดอันตรายและผลข้างเคียงของการผ่าตัด percutaneous nephrolithotomy (PCNL)*

วัสดุและวิธีการ*: ทำการศึกษาปัจจัยเสี่ยงที่สามารถทำให้เกิดอันตรายและผลข้างเคียงของการผ่าตัด PCNL โดยใช้แบบการศึกษา prospective descriptive study ในผู้ป่วยที่มาทำผ่าตัด PCNL เป็นครั้งแรก จำนวน 128 คนซึ่งได้รับการดมยาสลบและผ่าตัดแบบมาตรฐานทั่วไป และได้รับยาปฏิชีวนะก่อนลงมือผ่าตัด ผู้ป่วยได้รับ 0.9% NSS ที่อุณหภูมิห้องเป็น irrigation fluid การวิเคราะห์ทางสถิติโดยใช้ adjusted odds ratio (OR), 95%CI และ p value < 0.05*

ผลการศึกษา*: ผลข้างเคียงและอันตรายที่เกิดขึ้นระหว่างผ่าตัด PCNL คือ ผู้ป่วยส่วนหนึ่งมีอุณหภูมิกายต่ำลง เลือดออกปริมาณมาก และความดันโลหิตเปลี่ยนแปลงมากกว่า 20% ของค่าปกติ ซึ่งสัมพันธ์กับปริมาณของ irrigation fluid ที่ใช้ในขนาดมากกว่า 20 ลิตรอย่างมีนัยสำคัญทางสถิติ (p < 0.05) ส่วนผลข้างเคียงและอันตรายที่เกิดขึ้นในระยะหลังผ่าตัดคือเยื่อหุ้มปอดฉีก (3 ราย) เสียเลือดปริมาณมากและมีการติดเชื้อ พบภาวะติดเชื้อรุนแรง จนเกิดภาวะช็อกได้ถึงร้อยละ 4.7 (6/128) และมีอัตราตายร้อยละ 0.78 (1/128) การติดเชื้อสัมพันธ์กับ ปริมาณเลือดที่ได้รับหลังผ่าตัดที่ ≥ 1 ยูนิต (adjusted OR 4.9, p < 0.05) ขณะที่เลือดที่ออกปริมาณมาก ในระยะหลังผ่าตัดสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับระยะเวลาของการผ่าตัด (adjusted OR 4.4, p < 0.05) และภาวะเลือดออกปริมาณมากตั้งแต่ในระยะผ่าตัด (adjusted OR 10, p < 0.01) รวมทั้งภาวะติดเชื้อหลังผ่าตัด (adjusted OR 4.92, p < 0.01) ค่า mean และ mode ของระยะเวลาของการอยู่โรงพยาบาลภายหลังผ่าตัด (LOS_{PO}) คือ 7.31 ± 5.22 และ 5 วัน ซึ่งการที่ต้องอยู่โรงพยาบาลนานขึ้นกว่า 5 วันนั้นสัมพันธ์กับไข้ที่สูงกว่า 38.5°ซ. อย่างมีนัยสำคัญทางสถิติ (adjusted OR 2.7, p < 0.05)*

สรุป*: ผลข้างเคียงขณะผ่าตัดของ PCNL คืออุณหภูมิกายต่ำลงและความดันโลหิตเปลี่ยนแปลงซึ่งสัมพันธ์กับจำนวน irrigation fluid (ซึ่งเก็บในอุณหภูมิห้อง) ที่มากกว่า 20 ลิตรอย่างมีนัยสำคัญทางสถิติ ผลข้างเคียงที่สำคัญในระยะหลังผ่าตัดคือการติดเชื้อและเสียเลือด ซึ่งการติดเชื้ออาจรุนแรงจนถึงช็อกและเสียชีวิต นอกจากนี้ยังทำให้ต้องอยู่โรงพยาบาลนานขึ้น แม้จะเริ่มให้ยาปฏิชีวนะตั้งแต่หลังดมยาสลบ (prophylaxis antibiotic) ก็ไม่สามารถหยุดยั้งภาวะติดเชื้อในช่วงเวลาผ่าตัดและหลังผ่าตัดได้ทั้งหมด*