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Review Article

A meta analysis on the treatment of renal calculus by percutaneous nephroscope set and retrograde intra renal surgery

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Abstract: This meta analysis was focused on the comparison using percutaneous nephroscope set and retrograde intra renal surgery to treat renal calculus. The data were obtained from PubMed and Web of Science databases. The published time of literature were from March, 2014, the language included Chinese and English. The literature selection strategies were based on the evaluation and meta analysis on the preferred reporting items. The subgroup analysis comparison criteria were percutaneous nephrolithotomy (PCNL) minimally invasive percutaneous procedures (MIPPs), which included the comparison among mini-PCNL, micro-PCNL and RIRS. The research objects were selected from adult population. The searching words included: percutaneous nephrolithotomy, retrograde intrarenal surgery, percutaneous lithotripsy, RIRS, miniPCNL, micropercutaneous nephrolithtomy, flexible ureteroscopy. The efficiency of calculus removal, complication rate and hemoglobin decline rate after treatment were compared. PCNL had higher efficiency of calculus removal, but also had relatively higher complication rate, hemorrhage and longer hospitalization time. The standard efficiency of calculus removal for PCNL was higher than that of RIRS, while RIRS was better than MIPPs. Considering the complication and low efficacy, if the calculus was less than 2 cm, we should consider the use of RIRS standard treatment.

Keywords: Percutaneous nephroscope set, retrograde intra renal surgery, renal calculus, meta analysis

Introduction

Recently, minimally invasive surgery replaced the open operation to treat renal calculi gradually [1-3]. We used percutaneous nephrolithotomy (PCNL) to treat renal calculus which the diameter was larger than 2 cm [4]. While with the increasing complete clearance rate of renal calculi, the complication rate of the treatment also increased. To solve this problem, two kinds of minimally invasive percutaneous procedures (MIPPs) including mini-PCNL and micro-PCNL were used [4, 5]. Another kind of percutaneous treatment of renal calculus surgery was retrograde intra renal stone removal (RIRS), which was recommended by European Association for the urinary tract in 2013. If the anatomic structure was not suitable for using laser lithotripsy, then applied PCNL and RIRS would be the best choices for treating lower urinary calculi [6-8]. The aim of this study is to compare the advantages and disadvantages of using RIRS and MIPP to treat renal calculus.

Material and methods

The selection of the included literature

The data were obtained from PubMed and Web of Science databases. The published time of literature were from March, 2014, the language included Chinese and English. The literature selection strategies were based on the evaluation and meta analysis on the preferred reporting items. The subgroup analysis comparison criteria were PCNL minimally invasive percutaneous surgery (MIPPS), which included the comparison among mini-PCNL, micro-PCNL and RIRS. The research objects were selected from adult population. Keywords included: percutaneous nephrolithotomy, retrograde intrarenal surgery, percutaneous lithotripsy, RIRS, miniPCNL, micropercutaneous nephrolithtomy, flexible ureteroscopy.

Literature retrieval strategies were based on Preferred Reporting Items for Systematic Re-

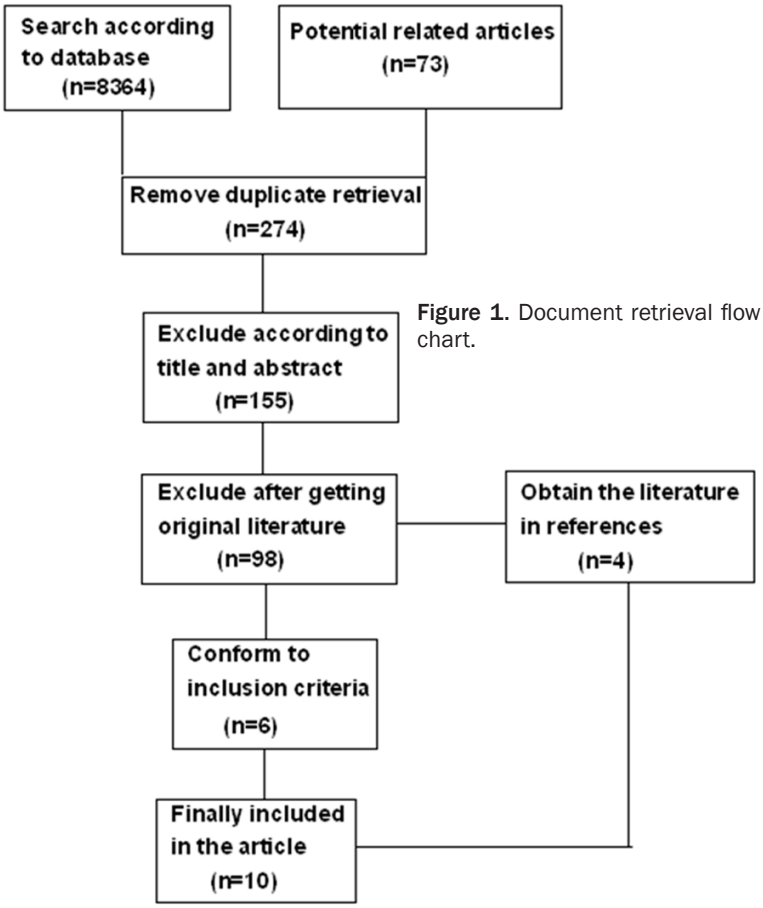

Figure 1. Document retrieval flow chart.

views and Meta-analysis criteria (**Figure 1**). Only the study on the analysis and comparison between PCNL and RIRS would be included [9, 10]. We also retrieved the references which were included in this study. The abstract of the study was not included in this study, because it did not describe the research method in detail. There were two authors retrieving independently, who discussed and reached agreement on the differences in the study.

Statistics

Meta analysis was performed to assess the overall evaluation of PCNL and RIRS procedures. The subgroup analyzed and compared standard PCNL (the size of sheath was more than 24F) plus RIRS method and MIPPS plus RIRS method. The extracted data included the length of operation, the amount of bleeding during operation, hospitalization time, help program and the complication rate after operation.

Odds ratio (RO) was adopted to compare binary variables, and the average deviation and standardized mean difference was used to describe continuous parameters. For some studies, if we chose to use average value and valid data range to describe the data, then we would apply the method described by Hozo for calculating the standard deviations [11]. If the heterogeneity detection showed no obvious difference, then we would use fixed effect model (Mantel-Haenszel method) [12, 13] to calculate total estimated value or used random effect model (DerSimonian-Laird method) [13, 14]. The merger effect was assessed by z examination. If $P < 0.05$, the differences had significant statistical difference. Cochrane chisquare test and the differences (I^2) were used to estimate the heterogenicity among the researches. The data analysis was processed by Review Manager software (RevMan v.5.1, Cochrane Collaboration, Oxford, UK) software.

The features of the included researches

Finally 10 researches were included in the statistical analysis, including 697 PCNL operations and 545 RIRS operations. The patients' age of PCNL group and RIRS group was 44.8 and 45.07 years old, the body mass index was 24 kg/m^2 and 24.1 kg/m^2 respectively. And there was no statistical difference. Four studies compared RIRS and standard PCNL operation [15-18], four studies compared RIRS and miniperc [13, 19-21], one study compared RIRS and microperc operation [22], six studies were retrospective case control study [12, 13, 15, 16, 18, 20], two of them were prospective case control study [19, 21]. The operations of the PCNL and RIRS were not same, the differences in the operation pointer of the multiple renal calculi was that megalo-ureter, the usage of sheathe and stent intervention which was in one of the MIPP research [18] and one PCNL

Table 1. Literature comparison of percutaneous renal stone removal and retrograde renal surgery

Study	Research institute (country)	Research project	Research design	LE	PCNL technique	PCNL	RIRS	
Akman et al. [15]	Haseki hospital (Turkey)	2008-2011	pair analysis	3 b	Standard (30 F)	34	34	6*
Bozkurt et al. [16]	Kecioren hospital (Turkey)	2008-2010	Retrospective case control	3 b	Standard (24 F)	42	37	6*
Bryniarski et al. [17]	Silesiamedical college (Poland)	2009-2011	RCT	2 b	Standard (24 F)	32	32	3º
Sabnis et al. [19]	Muljibhai Patel hospital (India)	2007-2012	prospective case control	3 b	Small (16-19 F)	32	32	6*
Ozturk et al. [18]	Diskapi Yildirim Beyazithospital (Turkey)	2009-2012	Retrospective case control	3 b	Standard (30 F)	144	38	5*
Kirac et al. [20]	Koru hospital (Turkey)	2011-2012		3 b	(16-18 F)	37	36	6*
Sabnis et al. [22]	Muljibhai Patelhospital (India)	2011-2012	RCT	2 b	(16 g)	35	35	3º
Kruck et al. [13]	Organizations (Germany)	2001-2007	Retrospective case control	3 b	(16-19 F)	172	108	4*
Resorlu et al. [12]	Organizations (Turkey)		Retrospective case control	3 b	(12-30 F)	140	46	6*
Pan et al. [21]	Yan Chai Hospital (China)	2005-2011	prospective case control	3 b	(18 F)	59	56	6*

LE = level of evidence; PCNL = percutaneous nephrolithotripsy; RCT = randomized controlled trial; RIRS = retrograde intrarenal surgery. *Using Newcastle-Ottawa Scale (score from 0 to 9). 8 Using Jadad scale (score from 0 to 5).

Table 2. Stone size, multiple stones and stone position

Study	Stone size		Multiple stones (%)		Stone position							
					Higher level		Middle level		Low level		Pelvis	
	PCNL	RIRS	PCNL	RIRS	PCNL	RIRS	PCNL	RIRS	PCNL	RIRS	PCNL	RIRS
Akman et al. [15]	270*	286*	32.4	17.6	17.6	17.6	5.8	5.8	41.2	44.1	35.3	32.4
Bozkurt et al. [16]	170*	165*	40.4	51.3	–	–	–	–	–	–	–	–
Bryniarski et al. [17]	352*	414*	–	–	–	–	–	–	–	–	–	–
Sabnis et al. [19]	15.2	14.2	21.8	34.4	3.1	9.4	0	3.1	31.2	28.1	43.7	25
Ozturk et al. [18]	17.4	17.3	–	–	–	–	–	–	100	100	–	–
Kirac et al. [20]	10.5	10.2	23.4	27.0	–	–	–	–	100	100	–	–
Sabnis et al. [22]	1.1	1	–	–	8.5	5.78	8.57	8.57	42.8	48.6	40	37.1
Kruck et al. [13]	12.6	6.8	–	–	–	–	–	–	42.7	76.8	–	–
Resorlu et al. [12]	17.3	15.6	15.7	21.7	12.1#	15.2#	–	–	38.6	30.4	33.6	32.6
Pan et al. [21]	22.4	22.3	–	–	8.5	12.5	18.6	12.5	53	51.8	19.9	23.2

PCNL = percutaneous nephrolithotripsy; RIRS = retrograde intrarenal surgery. *unite was mm^2, other unite was mm. #Upper and middle pole stones.

research [15]. Normal stent intervention was mentioned in three studies [15, 17, 21], most stent intervention stayed 1-2 weeks in the body (**Tables 1-3**)

Results

Overall analysis

For the evaluation of PCNL and RIRS treatment, there was no obvious difference in the duration of operation, weighted mean difference (WMD: -4.81 min; 95% CI, -14.05 to 4.43; P = 0.31). The stone-free rate of PCNL operation was higher (OR: 2.19; 95% CI, 1.53-3.13; P < 0.001), but at the same time, there were more complications (OR: 1.61; 95% CI, 1.11-2.35; P < 0.001), and hemoglobin decreased greatly (WMD: 0.87 g/dl; 95% CI, 0.51-1.22; P < 0.001, **Figure 2A-E**). The hospitalization time after RIRS operation was shorter (WMD: 1.28 d; 95% CI, 0.79-1.77; P < 0.001).

Subgroup analysis

Standard percutaneous nephrolithotomy: The stone elimination rate of standard PCNL was relatively higher (OR: 4.32; 95% CI, 1.99~9.37; P = 0.0002). But the length of the operation had no obvious difference (WMD: -9.21 min; 95% CI, -28.80~10.38; P = 0.36). There was also no obvious difference in the complication after operation (OR: 1.59; 95% CI, 0.84-3.02; P = 0.16, **Figure 3A-D**). While the hospitalization time was longer and RIRS was shorter (WMD: 1.84 d; 95% CI, 0.64-3.04; P = 0.003).

Minimally invasive percutaneous procedures (MIPPs): Compared with RIRS, the length of MIPPs was shorter (WMD -6.75 min; 95% CI,

Table 3. Summary of the operation methods: the usage of percutaneous nephroscope set and Retrograde renal surgery

	Akman et al. [15]	Bozkurt et al. [16]	Bryniarski et al. [17]	Sabnis et al. [19]	Ozturk et al. [18]	Kirac et al. [20]	Sabnis et al. [22]	Kruck et al. [13]	Resorlu et al. [12]	Pan et al. [21]
PCNL skills										
Imaging	F		F	US	F	F	F/US	F/US	F	US
Access			Urologist			Urologist	Urologist			
Sheath size, F	30	24	30	16-19	30	16-18	4.5	16-18	12-30	18
Dilator										
Balloon	X	X				X			X	
Metal			X		X			X	X	X
Amplatz		X				X				
Lithotripsy technique										
Pneumatic		X			X	X			X	
Ultrasonic		X	X			X	X		X	X
Laser		X		X						X
Grasper removal		X		X		X			X	
NT	R	S		S		S	None	None	S	R
RIRS										
Safety wire	X	X				X			X	
UAS	S	S		S	R	R	R		S	R
Dilator										
Fascial				X		X	X	X	X	X
Semirigid URS	X		X							X
Technique										
Dust		X	X	X		X	X		X	X
Basket				X			X			
Relocation of LP				X			X			X
Laser setting, W	8-10		15	15			5-15			10-15
Stent	R	S	R	S		S	S		S	R

-12.97 to -0.52; P = 0.03), but the clearance rate of RIRS was better (OR: 1.70; 95% CI, 1.07-2.70; P = 0.03, **Figure 4A-D**). And the hospitalization time of RIRS after the operation was also shorter (WMD: 1.11 d; 95% CI, 0.39-1.83; P = 0.003). There was no obvious difference in the complication between RIRS and MIPPs (OR: 1.46; 95% CI, 0.87-2.45; P = 0.15).

Discussion and conclusion

In this study, a meta analysis processed the comparison between three kinds of PCNL skills (standard, small-sized and minitype) and RIRS by the first overall analysis. Then the analysis of two subgroup was processed, one of the standard was only PCNL, another was MIPPs (miniperc and microperc).

There was no obvious difference in operation duration between PCNL and RIRS. Five studies showed that the operation duration of PCNL was short, while another two studies showed that RIRS was faster [22, 23]. If only compared with MIPPs, statistical result of subgroup analysis showed that PCNL had obvious advantages, including (WMD: 6.75 min; 95% CI, 12.97 to 0.52; *p* value = 0.03). Percutaneous urinary calculi removal showed the differences in the changes of image, dilation technique, size of sheath, stone-crusher, type/possition of the stone, ureteral stent implantation, road seal and etc among the illness case were very great during the operation.

Stone-free rate was the most important parameter in the evaluation of urinary surgery. The overall analysis showed that the stone-free rate of PCNL was obviously higher than that of RIRS (OR: 2.19; 95% CI, 1.53-3.13; P < 0.00001), which was different from the result of subgroup analysis, the stone-free rate of standard PCNL was better than that of RIRS, while RIRS was better than MIPPs. Stone-free rate related to the feature of stone, one of them explained the removal condition of MIPPs and PCNL on Multiple calculus [24]. The stone size of most PNCL studies was more than 2 cm, while the

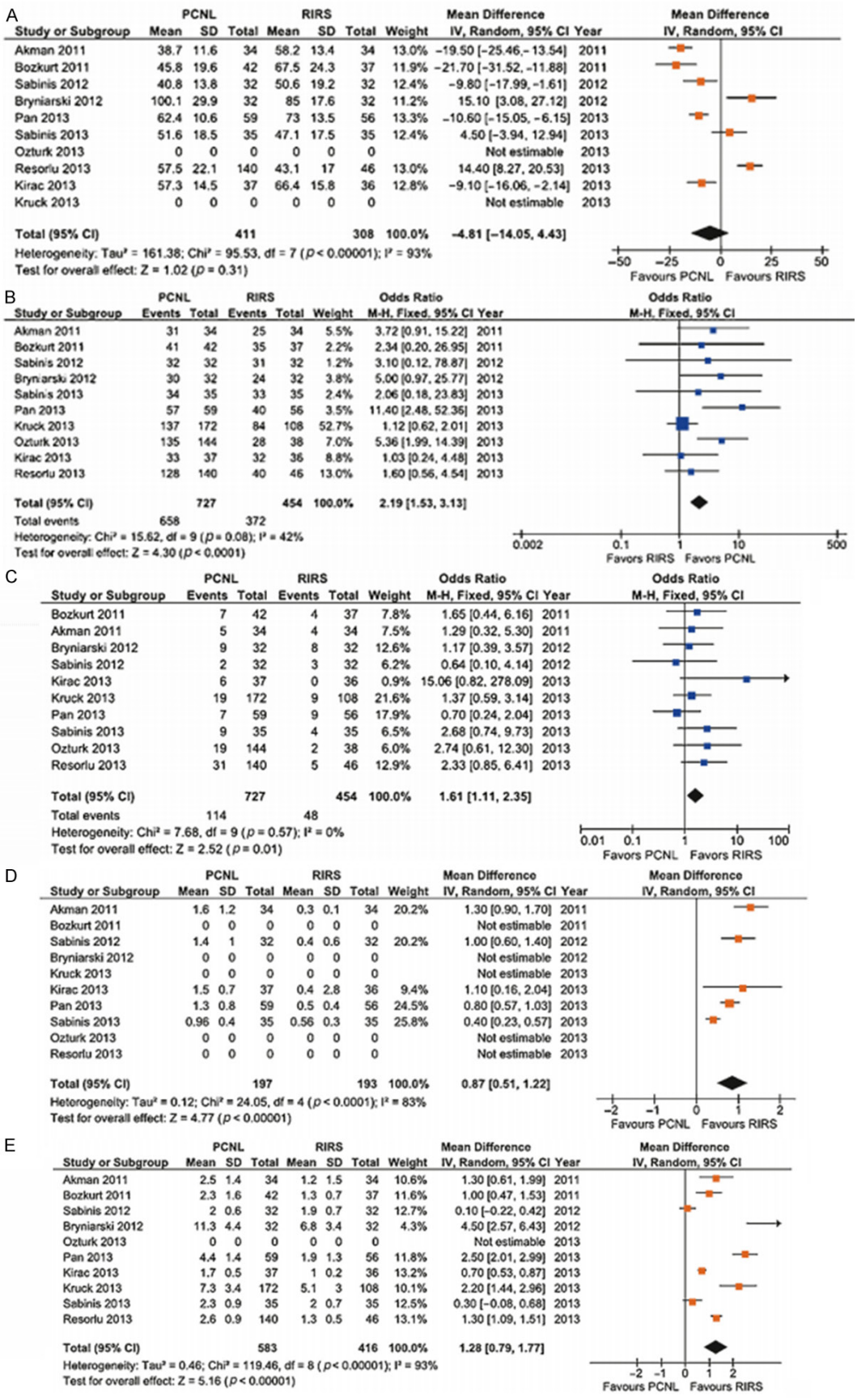
A
PCNL
RIRS
Mean Difference
Mean Difference
Study or Subgroup Mean SD Total Mean SD Total Weight IV, Random, 95% CI Year
IV, Random, 95% CI
Akman 2011 38.7 11.6 34 58.2 13.4 34 13.0% -19.50 [-25.46,-13.54] 2011
Bozkurt 2011 45.8 19.6 42 67.5 24.3 37 11.9% -21.70 [-31.52,-11.88] 2011
Sabinis 2012 40.8 13.8 32 50.6 19.2 32 12.4% -9.80 [-17.99,-1.61] 2012
Bryniarski 2012 100.1 29.9 32 85 17.6 32 11.2% 15.10 [3.08, 27.12] 2012
Pan 2013 62.4 10.6 59 73 13.5 56 13.3% -10.60 [-15.05,-6.15] 2013
Sabinis 2013 51.6 18.5 35 47.1 17.5 35 12.4% 4.50 [-3.94, 12.94] 2013
Ozturk 2013 0 0 0 0 0 0 Not estimable 2013
Resorlu 2013 57.5 22.1 140 43.1 17 46 13.0% 14.40 [8.27, 20.53] 2013
Kirac 2013 57.3 14.5 37 66.4 15.8 36 12.8% -9.10 [-16.06,-2.14] 2013
Kruck 2013 0 0 0 0 0 0 Not estimable 2013
Total (95% CI) 411 308 100.0% -4.81 [-14.05, 4.43]
Heterogeneity: Tau² = 161.38; Chi² = 95.53, df = 7 (p < 0.00001); I² = 93%
Test for overall effect: Z = 1.02 (p = 0.31)
-50 -25 0 25 50
Favours PCNL Favours RIRS
B
PCNL
RIRS
Odds Ratio
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Fixed, 95% CI Year
M-H, Fixed, 95% CI
Akman 2011 31 34 25 34 5.5% 3.72 [0.91, 15.22] 2011
Bozkurt 2011 41 42 35 37 2.2% 2.34 [0.20, 26.95] 2011
Sabinis 2012 32 32 31 32 1.2% 3.10 [0.12, 78.87] 2012
Bryniarski 2012 30 32 24 32 3.8% 5.00 [0.97, 25.77] 2012
Sabinis 2013 34 35 33 35 2.4% 2.06 [0.18, 23.83] 2013
Pan 2013 57 59 40 56 3.5% 11.40 [2.48, 52.36] 2013
Kruck 2013 137 172 84 108 52.7% 1.12 [0.62, 2.01] 2013
Ozturk 2013 135 144 28 38 7.0% 5.36 [1.99, 14.39] 2013
Kirac 2013 33 37 32 36 8.8% 1.03 [0.24, 4.48] 2013
Resorlu 2013 128 140 40 46 13.0% 1.60 [0.56, 4.54] 2013
Total (95% CI) 727 454 100.0% 2.19 [1.53, 3.13]
Total events 658 372
Heterogeneity: Chi² = 15.62, df = 9 (p = 0.08); I² = 42%
Test for overall effect: Z = 4.30 (p < 0.0001)
0.002 0.1 1 10 500
Favors RIRS Favors PCNL
C
PCNL
RIRS
Odds Ratio
Odds Ratio
Study or Subgroup Events Total Events Total Weight M-H, Fixed, 95% CI Year
M-H, Fixed, 95% CI
Bozkurt 2011 7 42 4 37 7.8% 1.65 [0.44, 6.16] 2011
Akman 2011 5 34 4 34 7.5% 1.29 [0.32, 5.30] 2011
Bryniarski 2012 9 32 8 32 12.6% 1.17 [0.39, 3.57] 2012
Sabinis 2012 2 32 3 32 6.2% 0.64 [0.10, 4.14] 2012
Kirac 2013 6 37 0 36 0.9% 15.06 [0.82, 278.09] 2013
Kruck 2013 19 172 9 108 21.6% 1.37 [0.59, 3.14] 2013
Pan 2013 7 59 9 56 17.9% 0.70 [0.24, 2.04] 2013
Sabinis 2013 9 35 4 35 6.5% 2.68 [0.74, 9.73] 2013
Ozturk 2013 19 144 2 38 6.0% 2.74 [0.61, 12.30] 2013
Resorlu 2013 31 140 5 46 12.9% 2.33 [0.85, 6.41] 2013
Total (95% CI) 727 454 100.0% 1.61 [1.11, 2.35]
Total events 114 48
Heterogeneity: Chi² = 7.68, df = 9 (p = 0.57); I² = 0%
Test for overall effect: Z = 2.52 (p = 0.01)
0.01 0.1 1 10 100
Favors PCNL Favors RIRS
D
PCNL
RIRS
Mean Difference
Mean Difference
Study or Subgroup Mean SD Total Mean SD Total Weight IV, Random, 95% CI Year
IV, Random, 95% CI
Akman 2011 1.6 1.2 34 0.3 0.1 34 20.2% 1.30 [0.90, 1.70] 2011
Bozkurt 2011 0 0 0 0 0 0 Not estimable 2011
Sabinis 2012 1.4 1 32 0.4 0.6 32 20.2% 1.00 [0.60, 1.40] 2012
Bryniarski 2012 0 0 0 0 0 0 Not estimable 2012
Kruck 2013 0 0 0 0 0 0 Not estimable 2013
Kirac 2013 1.5 0.7 37 0.4 2.8 36 9.4% 1.10 [0.16, 2.04] 2013
Pan 2013 1.3 0.8 59 0.5 0.4 56 24.5% 0.80 [0.57, 1.03] 2013
Sabinis 2013 0.96 0.4 35 0.56 0.3 35 25.8% 0.40 [0.23, 0.57] 2013
Ozturk 2013 0 0 0 0 0 0 Not estimable 2013
Resorlu 2013 0 0 0 0 0 0 Not estimable 2013
Total (95% CI) 197 193 100.0% 0.87 [0.51, 1.22]
Heterogeneity: Tau² = 0.12; Chi² = 24.05, df = 4 (p < 0.0001); I² = 83%
Test for overall effect: Z = 4.77 (p < 0.00001)
-2 -1 0 1 2
Favours PCNL Favours RIRS
E
PCNL
RIRS
Mean Difference
Mean Difference
Study or Subgroup Mean SD Total Mean SD Total Weight IV, Random, 95% CI Year
IV, Random, 95% CI
Akman 2011 2.5 1.4 34 1.2 1.5 34 10.6% 1.30 [0.61, 1.99] 2011
Bozkurt 2011 2.3 1.6 42 1.3 0.7 37 11.6% 1.00 [0.47, 1.53] 2011
Sabinis 2012 2 0.6 32 1.9 0.7 32 12.7% 0.10 [-0.22, 0.42] 2012
Bryniarski 2012 11.3 4.4 32 6.8 3.4 32 4.3% 4.50 [2.57, 6.43] 2012
Ozturk 2013 0 0 0 0 0 0 Not estimable 2013
Pan 2013 4.4 1.4 59 1.9 1.3 56 11.8% 2.50 [2.01, 2.99] 2013
Kirac 2013 1.7 0.5 37 1 0.2 36 13.2% 0.70 [0.53, 0.87] 2013
Kruck 2013 7.3 3.4 172 5.1 3 108 10.1% 2.20 [1.44, 2.96] 2013
Sabinis 2013 2.3 0.9 35 2 0.7 35 12.5% 0.30 [-0.08, 0.68] 2013
Resorlu 2013 2.6 0.9 140 1.3 0.5 46 13.1% 1.30 [1.09, 1.51] 2013
Total (95% CI) 583 416 100.0% 1.28 [0.79, 1.77]
Heterogeneity: Tau² = 0.46; Chi² = 119.46, df = 8 (p < 0.00001); I² = 93%
Test for overall effect: Z = 5.16 (p < 0.00001)
-2 -1 0 1 2
Favours PCNL Favours RIRS

Figure 2. Statistical forest map: A: Operation time, B: Stone removal rate, C: Finished rate, D: HP decline, E: Hospitalization time.

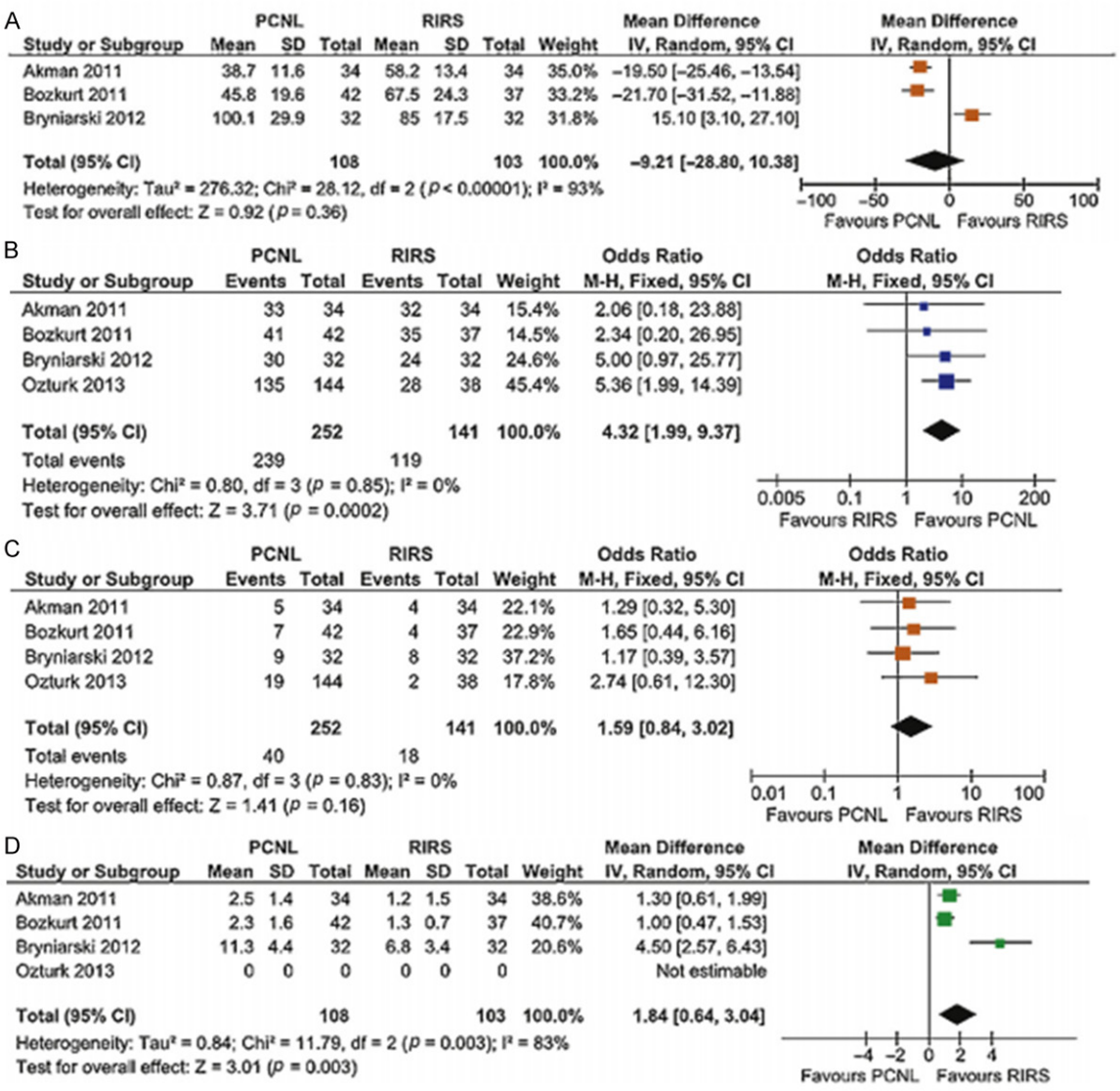

Figure 3. Forest map of percutaneous percutaneous nephrolithotripsy subgroup: A: Operation time, B: Stone removal rate, C: Finished rate, D: Hospitalization time.

stone size was relatively small for MIPPs operations. The position of the stone would also influence the removal efficiency. If the minimum of urethra was more than 1.5 cm, it would be more convenient to use percutaneous strategy, so it could reach the stone position directly. And the stone-free rate would be improved because the debris would be discharged with urine after operation.

The overall analysis showed that compared with RIRS, PCNL had higher complication rate (OR: 1.61; 95% CI, 1.11-2.35; P < 0.01). Fever (PCNL: 3-25%; RIRS: 2-28%), long-term use of antibiotics (PCNL: 2-8%; RIRS: 4-5%) and hematosepsis (PCNL: 0.5-2%; RIRS: 3-5%). Haemorrhage problem made most complications of PCNL [26], which mentioned that hemoglobin value was decreased (WMD: 0.87 g/deciliter; 95% CI, 0.51-1.22; P < 0.00001). 5.5% patients with PCNL received transfusion. Distinctive PCNL extended urinary extravasation (N = 4), embolism (N = 1), injury of pleura (N = 1) and pelvic perforation (N = 2) and ureteral injury (N

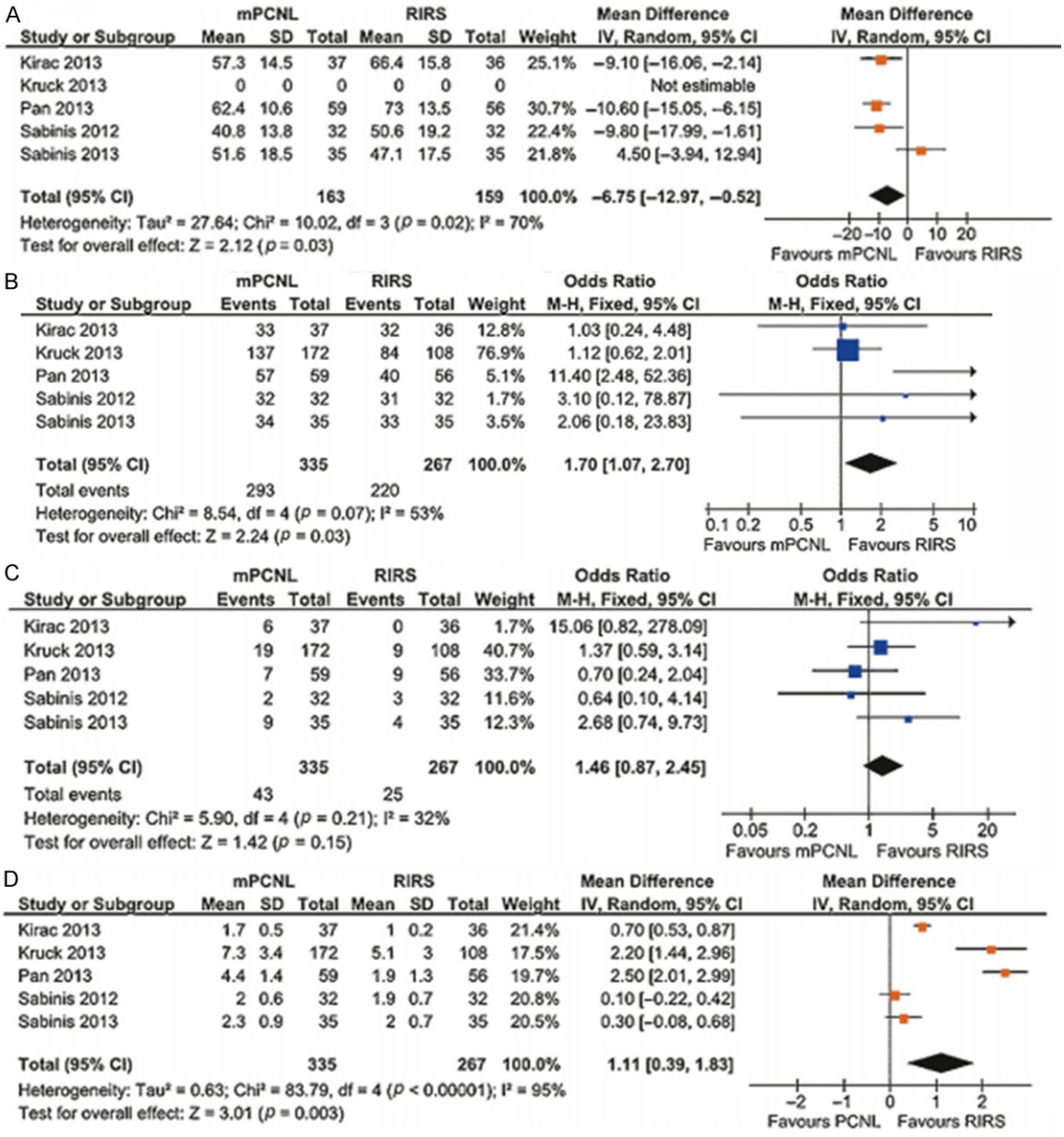

Figure 4. Forest map of Minimally invasive percutaneous procedure subgroup: A: Operation time, B: Stone removal rate, C: Finished rate, D: Hospitalization time.

= 2) needed to re-open (N = 1) specific RIRS. There was no obvious difference in the complication rate between MIPPs and standard PCNL, RIRS. Tyson and the colleagues reported that pulmonary disease (OR: 7.77), blood coagulation (OR: 6.16), anemia (OR: 3.82), paralysis (OR: 2.16) and other complications were the risk factor of increasing the expenses in the hospital [27].

Some parameters in this study had high heterogenicity. This kind of heterogenicity could be explained as the difference of surgery practice, follow-up method, follow-up frequency and results. The studies of MIPPs and RIRS should be compared by focusing on the operation of RIRS. Most of them used the ureter to enter sheath, semi rigid ureter mirror (dilated ureter), lower pole calculus shift and selective stent insertion. About percutaneous procedure, some studies [2, 21, 25] used intraoperative ultrasound imaging, follow up CT imaging and etc. The usage of these methods could also cause the bias in the results of the MIPPs study.

The meta analysis showed that compared with RIRS, PCNL could provide higher stone-free rate, but its complication rate was also higher, hemorrhage and hospitalization time was longer, but there was no obvious difference in operation time. While compared with MIPPs, RIRS could provide higher stone-free rate. Considering MIPPs could increase the mortality rate and decrease the stone-free rate, which stone diameter was less than 2 cm, RIRS should be regarded as the first choice for treating this kind of stone, while MIPPs could be adopted under the situation of the surgical instruments and the experience of the operator was not enough.

Disclosure of conflict of interest

None.

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