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REVIEW PAPER

UROLITHIASIS

Regional versus general anaesthesia in percutaneous nephrolithotomy: a systematic review and meta-analysis

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Introduction Several studies have compared the safety and effectiveness of general and regional anaesthesia in percutaneous nephrolithotomy (PCNL). This study aimed to compare the perioperative and postoperative outcomes of general anaesthesia and regional anaesthesia for patients undergoing PCNL.

Material and methods For relevant articles, three electronic databases, including PubMed, Scopus, and Web of Science, were searched from their inception until March 2023. A meta-analysis has been reported in line with PRISMA 2020 and AMSTAR Guidelines. The risk ratio (RR) and mean difference (MD) were applied for the comparison of dichotomous and continuous variables with 95% confidence intervals (CI).

Results The final cohort analysis, comprised 3871 cases of PCNL, (2154 regional anaesthesia and 1717 general anaesthesia). Compared to general anaesthesia, the regional anaesthesia group had a significantly shorter length of stay (MD = -0.34 days, 95% CI -0.56 to -0.12, p = 0.002), lower postoperative nausea and vomiting rates (RR = 0.16, 95% CI 0.03 to 0.80, p = 0.026), lower complications grade III–V rates (RR = 0.68, 95% CI 0.53 to 0.88, p = 0.004), and lower postoperative visual analogue pain score (VAS) at 1 hour (MD = -3.5, 95% CI -4.1 to -2.9, p <0.001). There were no significant differences in other outcomes between the two groups.

Conclusions Our results show that PCNL under regional anaesthesia is safe and feasible, with comparable results to those done under general anaesthesia. While patient selection is important, counselling and decision-making for these procedures must go hand in hand to achieve the best clinical outcome.

Key Words: kidney calculi ‹› percutaneous nephrolithotomy ‹› PCNL ‹› regional anaesthesia

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) is a minimally invasive procedure commonly used in Endourology and has become the standard for managing large and complex renal calculi [1]. From the first report by Fernstrom and Johansson in 1976, PCNL techniques have been modified to ameliorate safety, efficacy, and decrease morbidity [2].

In PCNL procedures, the choice of anaesthesia impacts the outcomes, especially in minimising respiratory complications and length of hospital stay. Both general anaesthesia and regional anaesthesia have their advantages. While general anaesthesia dominates in controlling patients' breathing and improving their comfort, regional anaesthesia has advantages with its lower rate of postoperative drug reactions and shorter procedural duration

and hospital stay [1]. Many studies have compared the safety and effectiveness of general and regional anaesthesia in the PCNL. However, the conclusions are inconsistent, and there is a lack of agreement on the optimal anaesthesia setting for PCNL. This study aimed to compare the perioperative and post-operative outcomes of general anaesthesia and regional anaesthesia for patients undergoing PCNL.

MATERIAL AND METHODS

Literature search

This study was conducted following the accepted methodology recommendations of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and AMSTAR (Assessing the Methodological Quality of Systematic Reviews) [3,4]. Three electronic databases, Scopus, Web of Science (ISI), and PubMed were searched to identify relevant studies regarding perioperative and post-operative outcomes of patients undergoing PCNL under regional anaesthesia or general anaesthesia from January 1980 to March 2023. The search terms included combinations of 'local', 'regional', 'locoregional', 'loco-regional', 'nerve' with 'anesthesia', 'anaesthesia', 'analgesia', 'block' and 'PCNL', 'percutaneous nephrolithotomy', 'percutaneous nephrolithotomy', 'percutaneous nephrolithotripsy', 'percutaneous stone lithotripsy', 'ECIRS', 'endoscopic combined intrarenal surgery', 'miniPCNL', 'mini-PCNL', 'microPCNL' and 'micro-PCNL'. Boolean operators (AND, OR) were used to refine the search. Additionally, we performed a manual search of references from articles included in Scopus, PubMed and Web of Science to avoid missing any relevant publications, and from reference lists of included articles [5].

Selection criteria and abstract screening

Inclusion criteria

1. Original articles reporting on the peri and postoperative outcomes of PCNL under anaesthesia.
2. Studies in the English language with a minimum of 20 patients.

Exclusion criteria

1. Not relevant to the study topic, in vitro or animal study
2. Review articles, book chapters, thesis
3. Conference papers, editorials, letters, oral presentations, correspondences, communications, and posters
4. Studies were done under regional anaesthesia where data on regional anaesthesia could not be separated from those who underwent general anaesthesia
5. Studies examining PCNL for non-urolithiasis conditions or ureteral stones
6. Studies that explicitly did not report SFR.

Two independent groups of reviewers (MS, TTN) performed title and abstract screening to select relevant papers. Eligible publications were further screened for inclusion in the systematic review and meta-analysis. Any disagreement was resolved by discussion and consensus (MS, TTN, BKS) if necessary.

Full-text screening and data extraction

Regarding data extraction, two authors (MS and TTN) developed the extraction form using Excel (Microsoft Corp., Redmond, WA, USA). All disagreements and discrepancies were resolved by discussion and consensus. Papers published by the same research group were checked for potential overlapping data based on the period of case recruitment, the center where the cases were recruited, and confirmation from the study authors when necessary. For those studies that selected patients from the same institutions or databases, we chose the studies with the highest number of patients or the most recent data for the primary analyses.

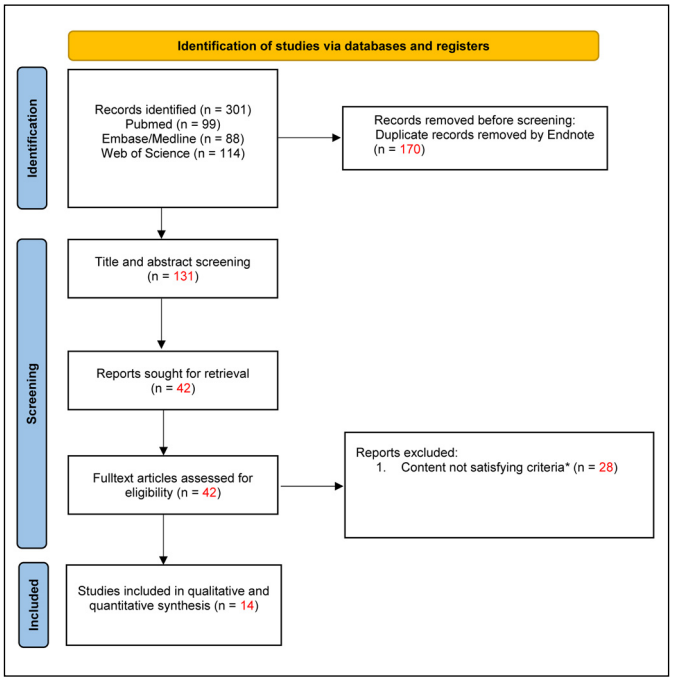


Figure 1. *Evidence acquisition flow chart.*

*Records excluded due to single-arm study design or lack of information related with perioperative outcomes

**Includes no reliable or overlapped data.

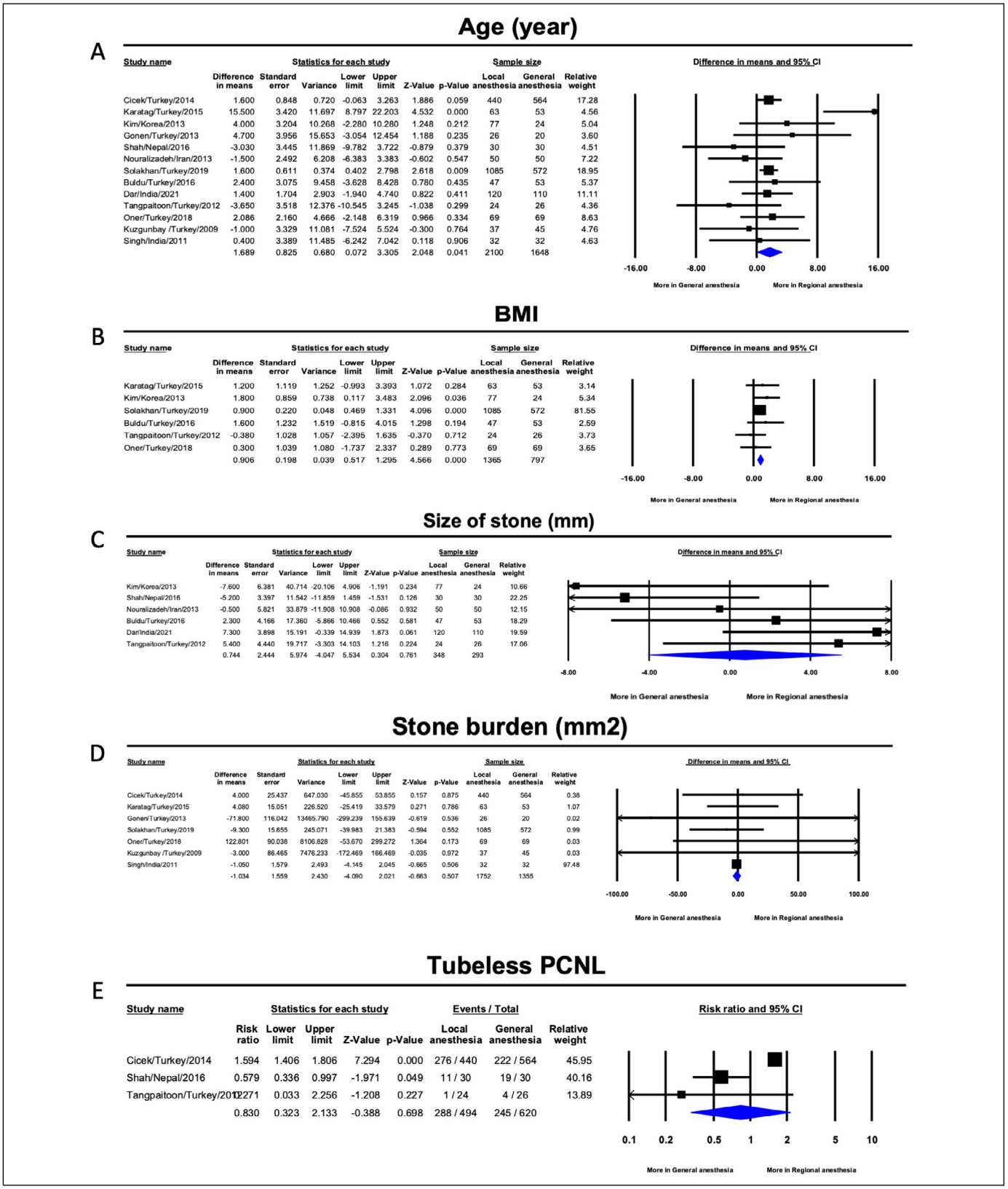


Figure 2. *Forest plots for the meta-analysis comparing the characteristics of percutaneous nephrolithotomy patients between regional anesthesia and general anesthesia groups:* **(a)** *Age;* **(b)** *BMI;* **(c)** *Size of stone;* **(d)** *Stone burden,* **(e)** *Tubeless percutaneous nephrolithotomy.*

PCNL – percutaneous nephrolithotomy

Table 1. *Characteristics of included studies*

Study ID (Author/Year/ Country)	Study design	No. of patients	Regional anesthesia	No. of cases		Percentages of males		Sedation		Position	Type of puncture	Type of lithotriptor	Sheath size (Fr)	Age (years)		BMI		ASA		Stone diameter (mm)		Stone burden (mm²)	
				Regional	General	Regional	General	Regional	General					Regional	General	Regional	General	Regional	General	Regional	General	Regional	General
Singh/India /2011 [9]	Randomized	64	L1–L2	32	32	NA	NA	no	no	Prone	Fluroscopy guidance	pneumatic	30	40	39.6	NA	NA	NA	NA	21.9	22.7	NA	NA
Kuzgunbay/Turkey/2009 [10]	Randomized	82	L3–L4	37	45	64.9	57.8	no	no	Prone	Fluroscopy guidance	pneumatic	30	44	45	NA	NA	NA	NA	NA	NA	731	734
Moslemi/ Iran/2012 [11]	Retrospective	123	L–2L3	54	69	NA	NA	NA	NA	Prone	Fluroscopy guidance	pneumatic	30–32	39	41	25	26	NA	NA	NA	NA	NA	NA
Oner/Turkey /2018 [12]	Retrospective	138	catheter at t12–L1, sensory level T6–S4	69	69	60.9	53.6	yes	no	Prone	Fluroscopy guidance	pneumatic	30	46.4	44.3	28.6	28.3	1.3	1.2	NA	NA	867.0	744.2
Tangpaitoon /Turkey/2012 [13]	Randomized	50	L1–L2	24	26	70.8	61.5	NA	NA	Prone	Fluroscopy guidance	pneumatic	30	53.0	56.6	21.2	21.6	23 (ASA 1–2), 1 (ASA 3)	25 (ASA 1–2), 1 (ASA 3)	40.8	35.4	NA	NA
Dar/India/2021 [14]	Prospective randomized	230	T9–T10or T10–T11	120	110	55.0	56.4	no	no	Prone	Fluroscopy guidance	laser/ Pneumatic	24–28	39.9	38.5	NA	NA	ASA 1–2	ASA 1–2	61.9	54.6	NA	NA
Buldu/Turkey /2016 [15]	Retrospective	100	L3–L4 (T4 dermato-me)	47	53	70.2	79.2	NA	NA	Prone	Fluroscopy guidance	pneumatic	30	48.5	46.1	28.7	27.1	1.4	1.2	52.9	50.6	NA	NA
Solakhan/Turkey /2019 [16]	Retrospective	1657	l2–l3	1085	572	66.6	59.6	no	no	Prone	Fluroscopy guidance	NA	30	34.3	32.7	25.1	24.2	128 (ASA 3)	106 (ASA 3)	NA	NA	635.2	644.5
Nouralizadeh/Iran /2013 [17]	Randomized	100	L3–L4, T6 dermato-me	50	50	58.0	54.0	no	no	Prone	Fluroscopy guidance	pneumati-c+laser	28–30	41.1	42.6	NA	NA	ASA 1–2	ASA 1–2	55.1	55.6	NA	NA
Gonen/Turkey /2013 [18]	Retrospective	46	L2–L3	26	20	69.2	65.0	no	no	Prone	Fluroscopy guidance	pneumatic	30	45.5	40.8	NA	NA	NA	NA	NA	NA	558.6	630.4
Shah/Nepal /2016 [19]	Randomized	60	l3–l4 (T6 dermatome)	30	30	43.3	63.3	yes	no	Prone	Fluroscopy guidance	pneumatic	26–30	36.1	39.1	NA	NA	ASA 1–2	ASA 1–2	32.3	37.5	NA	NA
Kim/Korea /2013 [20]	Retrospective	101	L3–4 or L4–5	77	24	61.0	58.3	yes	no	Prone	Ultrasound	ltrasonicand pneumatic lithotripsy	28–30	54.8	50.8	25.1	23.3	NA	NA	34.5	42.1	NA	NA
Cicek/Turkey /2014 [21]	Retrospective	1004	L2–L3	440	564	64.3	60.1	yes	no	Prone	Fluroscopy guidance	pneumatic	30	48.8	47.2	NA	NA	33 (ASA 3)	39 (ASA 3)	NA	NA	533	529
Karatag/Turkey /2015 [22]	Retrospective	116	L3–L4 or L4–L5; T4 dermatome	63	53	NA	NA	no	no	Prone	Fluroscopy guidance	laser	4.8	45.8	30.3	27	25.8	NA	NA	NA	NA	155.0	151

ASA – American Society of Anesthesiologists score; BMI – Body mass index; NA – Not available

Table 2. *Meta-analysis of the characteristics and perioperative outcomes of percutaneous nephrolithotomy patients between regional and general anesthesia groups*

Variables	No. of Studies	No. of patients		Heterogeneity		Overall effect	
		Regional	General	I^2 (%)	p-value	MD/RR (95% CI)	p-value
Age (year)	13	2100	1648	50	0.019	1.68 (0.07, 3.3)	0.041
BMI	6	1365	797	0	0.642	0.9 (0.51, 1.29)	<0.001
Size of stone (mm)	6	348	293	43	0.114	0.7 (-4.0, 5.5)	0.761
Stone burden (mm^2)	7	1752	1355	0	0.846	-1.03 (-4.09, 2.02)	0.507
Operative time (minute)	14	2154	1717	94	<0.001	-8.2 (-17.3, 0.8)	0.076
Length of stay (day)	12	2031	1579	89	<0.001	-0.34 (-0.56,-0.12)	0.002
Nephrostomy	2	470	594	0	0.863	0.61 (0.5, 0.7)	<0.001
Tubeless PCNL	3	494	620	86	0.001	0.83 (0.32, 2.13)	0.698
Need for auxiliary procedures	6	372	299	0	0.84	1.07 (0.7, 1.4)	0.678
Stone-free rates (SFR) at 1 month	14	2154	1717	0	0.923	1.01 (0.98, 1.03)	0.4
Blood transfusion	9	1827	1455	39	0.102	0.77 (0.5, 1.18)	0.231
Postoperative nausea and vomiting (PONV)	3	104	106	60	0.081	0.16 (0.03, 0.80)	0.026
Complications Grade I–II	14	2154	1717	38	0.07	0.98 (0.79, 1.21)	0.883
Complications Grade III–V	8	1883	1476	0	0.837	0.68 (0.53, 0.88)	0.004
Postoperative visual analog pain score at 1 hour	2	144	136	0	0.59	-3.5 (-4.1,-2.9)	<0.001
Postoperative visual analog pain score at 12 hours	2	144	136	0	0.708	-0.4 (-0.88, 0.03)	0.07
Postoperative visual analog pain score at 24 hours	2	144	136	0	0.885	-0.15 (-0.60, 0.30)	0.512
Opioid use	2	76	70	97	<0.001	-3.1 (-6.6, 0.3)	0.077

PCNL – percutaneous nephrolithotomy; CI – confidence interval; MD – mean difference; RR – risk ratio

Quality assessment

The Newcastle–Ottawa Scale (NOS) was used to evaluate the quality of studies included in our meta-analyses, in which stars were awarded for cohort or case-control studies (maximum nine stars) based on a developed checklist [6]. Studies that were awarded at least six stars were considered moderate- to high-quality studies, while those with a NOS value of less than six were regarded as low-quality studies [6].

Statistical analysis

A comprehensive Meta-analysis (Englewood, NJ, USA) was used for statistical analyses. Among-study heterogeneity was assessed by the I^2 statistic, which shows the total variation across studies that is not a result of chance [7]. An I^2 statistic ranging from 25–49%, 50–74%, and ≥75% indicates a low, moderate, and high heterogeneity, respectively [8]. Sensitivity or subgroup analyses were performed to handle heterogeneity. We used risk ratios (RR) with 95% confidential intervals (CI) for categorical variables. The pooled results are presented as a forest plot using random-effects models. Egger's regression test and funnel plot were calculated to assess the presence of publication bias. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Search results and study characteristics

A total of 301 articles were identified from three electronic databases, including Scopus, PubMed, and Web of Science. After screening those articles by title and abstract, 42 articles were selected for full-text assessment. Upon full-text review, 28 articles were excluded due to lack of proper information, study design, and duplication. In total, 14 articles that met the inclusion criteria were included in the final cohort analysis, comprising 3871 cases of PCNL, including 2,154 regional anaesthesia cases and 1717 general anaesthesia cases [9–22]. The evidence acquisition flow chart is shown in Figure 1. The individual characteristics of all included studies are described in Table 1.

Perioperative and postoperative outcomes after percutaneous nephrolithotomy

A summary of this meta-analysis of the characteristics and outcomes of two groups (regional anaesthesia and general anaesthesia) is demonstrated in Table 2. Compared to general anaesthesia, the regional anaesthesia group had a significantly higher age (MD = 1.68 years, 95% CI 0.07 to 3.30,

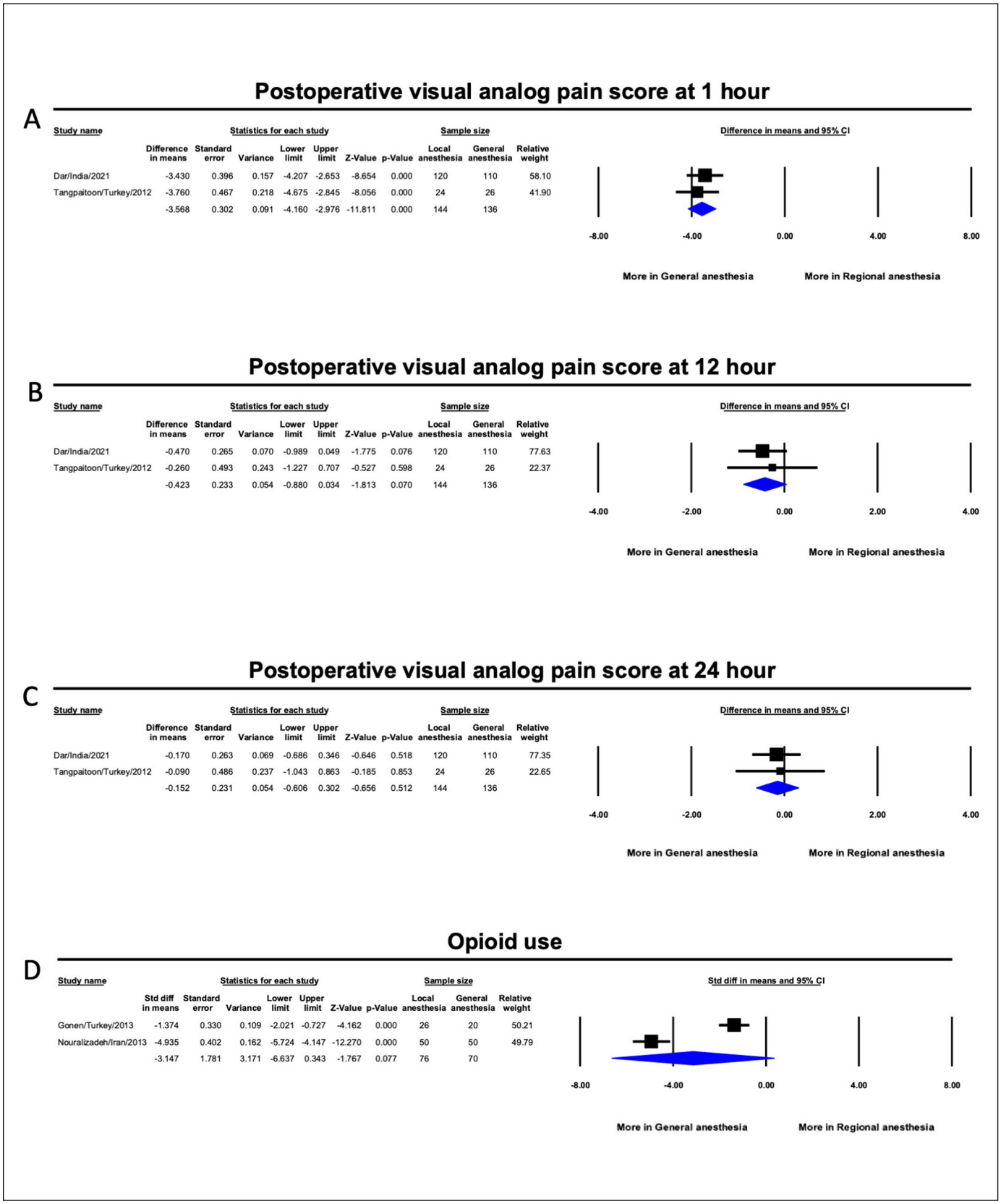


Figure 3. *Forest plots for the meta-analysis comparing the outcomes of percutaneous nephrolithotomy patients between regional anaesthesia and general anaesthesia groups:* **(a)** *Postoperative visual analog pain score at 1 hour;* **(b)** *Postoperative visual analog pain score at 12 hours;* **(c)** *Postoperative visual analog pain score at 24 hours;* **(d)** *Opioid use.*

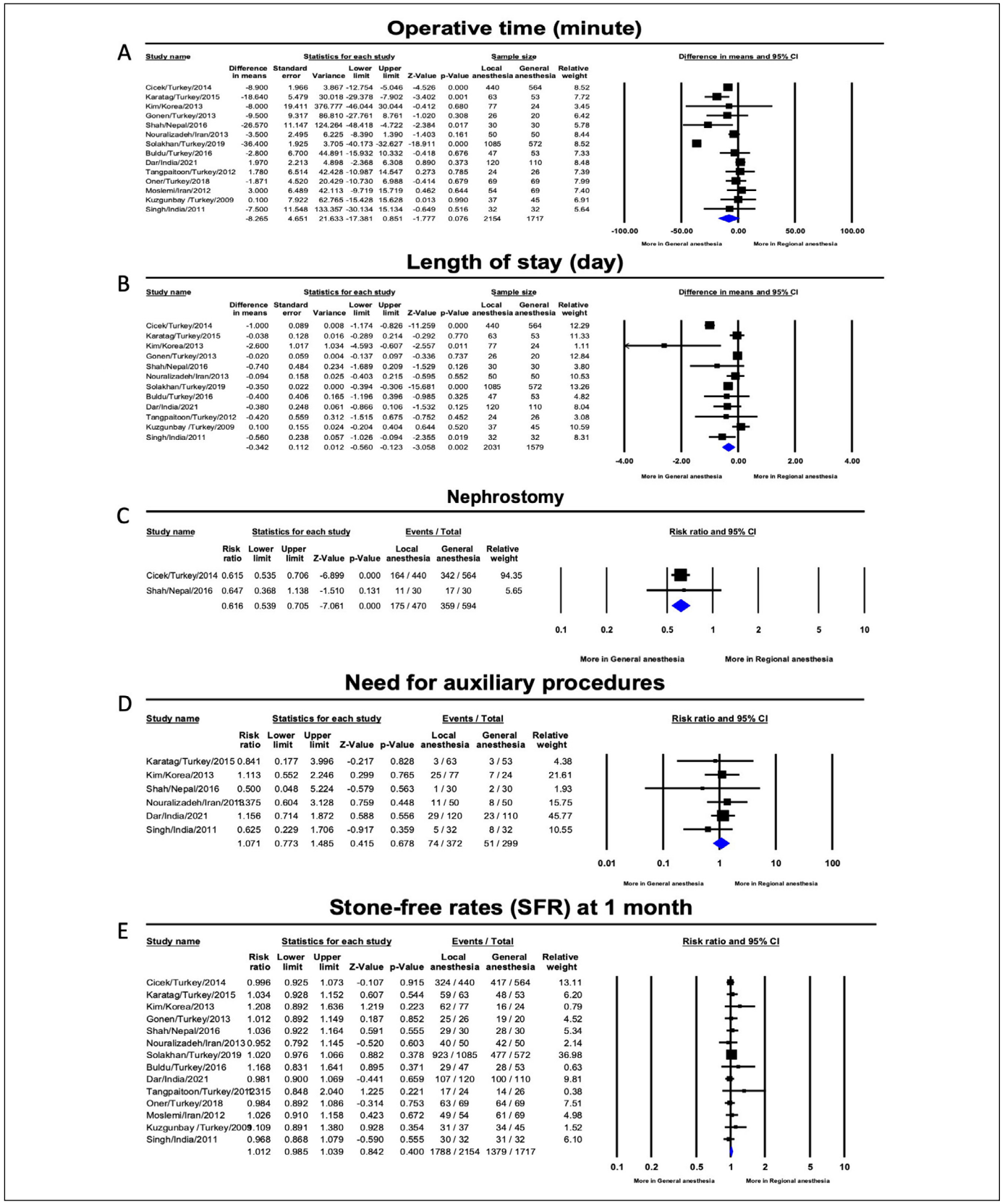
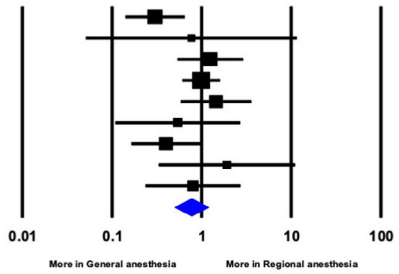


Figure 4. *Forest plots for the meta-analysis comparing the outcomes of percutaneous nephrolithotomy patients between local anesthesia and general anaesthesia groups:* **(a)** *Operative time;* **(b)** *Length of stay;* **(c)** *Nephrostomy;* **(d)** *Need for auxiliary procedures;* **(e)** *Stone-free rates (SFR) at 1 month.*

A

Blood transfusion

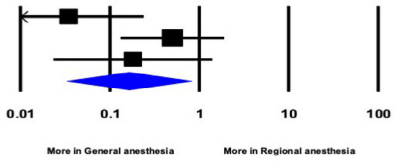
Study name	Risk ratio	Lower limit	Upper limit	Z-Value	p-Value	Local anesthesia	General anesthesia	Relative weight
Cicek/Turkey/2014	0.302	0.141	0.645	-3.091	0.002	8 / 440	34 / 564	15.66
Gonen/Turkey/2013	0.769	0.051	11.559	-0.190	0.849	1 / 26	1 / 20	2.30
Nouralizadeh/Iran/2013	1.250	0.538	2.904	0.519	0.604	10 / 50	8 / 50	14.06
Solakhan/Turkey/2019	0.988	0.609	1.605	-0.047	0.963	45 / 1085	24 / 572	22.19
Buldu/Turkey/2016	1.450	0.586	3.589	0.803	0.422	9 / 47	7 / 53	12.95
Tangpaitoon/Turkey/2012	0.542	0.109	2.694	-0.749	0.454	2 / 24	4 / 26	5.77
Oner/Turkey/2018	0.400	0.165	0.970	-2.027	0.043	6 / 69	15 / 69	13.30
Moslemi/Iran/2012	1.917	0.332	11.067	0.727	0.467	3 / 54	2 / 69	4.98
Singh/India/2011	0.800	0.236	2.710	-0.358	0.720	4 / 32	5 / 32	8.79
	0.770	0.502	1.180	-1.199	0.231	88 / 1827	100 / 1455	



B

Postoperative nausea and vomiting (PONV)

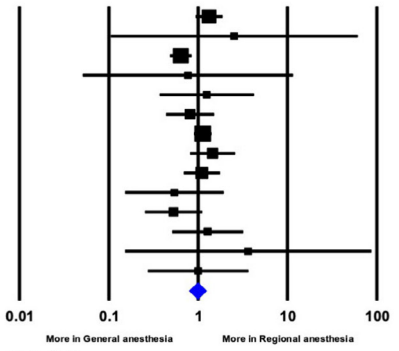
Study name	Risk ratio	Lower limit	Upper limit	Z-Value	p-Value	Local anesthesia	General anesthesia	Relative weight
Shah/Nepal/2016	0.034	0.005	0.237	-3.423	0.001	1 / 30	29 / 30	30.73
Nouralizadeh/Iran/2013	0.500	0.132	1.889	-1.022	0.307	3 / 50	6 / 50	40.13
Tangpaitoon/Turkey/2012	0.181	0.023	1.393	-1.642	0.101	1 / 24	6 / 26	29.14
	0.163	0.033	0.809	-2.219	0.026	5 / 104	41 / 106	



C

Complications Grade I-II

Study name	Risk ratio	Lower limit	Upper limit	Z-Value	p-Value	Local anesthesia	General anesthesia	Relative weight
Cicek/Turkey/2014	1.328	0.940	1.875	1.608	0.108	58 / 440	56 / 564	15.00
Karatag/Turkey/2015	2.531	0.105	60.871	0.572	0.567	1 / 63	0 / 53	0.44
Kim/Korea/2013	0.639	0.485	0.842	-3.188	0.001	41 / 77	20 / 24	17.55
Gonen/Turkey/2013	0.769	0.051	11.559	-0.190	0.849	1 / 26	1 / 20	0.60
Shah/Nepal/2016	1.250	0.371	4.207	0.360	0.719	5 / 30	4 / 30	2.72
Nouralizadeh/Iran/2013	0.813	0.438	1.507	-0.659	0.510	13 / 50	16 / 50	7.99
Solakhan/Turkey/2019	1.127	0.903	1.406	1.054	0.292	203 / 1085	95 / 572	19.59
Buldu/Turkey/2016	1.450	0.814	2.583	1.261	0.207	18 / 47	14 / 53	8.74
Dar/India/2021	1.100	0.692	1.748	0.403	0.687	30 / 120	25 / 110	11.37
Tangpaitoon/Turkey/2012	0.542	0.152	1.929	-0.946	0.344	3 / 24	6 / 26	2.50
Oner/Turkey/2018	0.529	0.254	1.105	-1.694	0.090	9 / 69	17 / 69	6.22
Moslemi/Iran/2012	1.278	0.513	3.184	0.526	0.599	8 / 54	8 / 69	4.43
Kuzgunbay /Turkey/2009	3.632	0.152	86.601	0.797	0.425	1 / 37	0 / 45	0.44
Singh/India/2011	1.000	0.274	3.656	0.000	1.000	4 / 32	4 / 32	2.41
	0.984	0.796	1.217	-0.147	0.883	395 / 2154	266 / 1717	



D

Complications Grade III-V

Study name	Risk ratio	Lower limit	Upper limit	Z-Value	p-Value	Local anesthesia	General anesthesia	Relative weight
Cicek/Turkey/2014	0.513	0.325	0.809	-2.867	0.004	24 / 440	60 / 564	31.30
Karatag/Turkey/2015	0.841	0.257	2.750	-0.286	0.775	5 / 63	5 / 53	4.65
Nouralizadeh/Iran/2013	0.500	0.096	2.607	-0.823	0.411	2 / 50	4 / 50	2.39
Solakhan/Turkey/2019	0.797	0.544	1.167	-1.165	0.244	62 / 1085	41 / 572	44.90
Dar/India/2021	0.786	0.272	2.266	-0.446	0.655	6 / 120	7 / 110	5.82
Tangpaitoon/Turkey/2012	2.240	0.138	75.915	0.731	0.465	1 / 24	0 / 26	0.66
Oner/Turkey/2018	1.000	0.064	15.668	0.000	1.000	1 / 69	1 / 69	0.86
Singh/India/2011	0.700	0.305	1.609	-0.840	0.401	7 / 32	10 / 32	9.42
	0.687	0.532	0.887	-2.880	0.004	108 / 1883	128 / 1476	

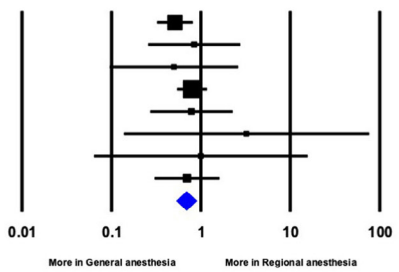


Figure 5. *Forest plots for the meta-analysis comparing the outcomes of percutaneous nephrolithotomy patients between regional anesthesia and general anesthesia groups:* **(a)** *Blood transfusion;* **(b)** *Postoperative nausea and vomiting (PONV);* **(c)** *Complications Grade I–II;* **(d)** *Complications Grade III–V.*

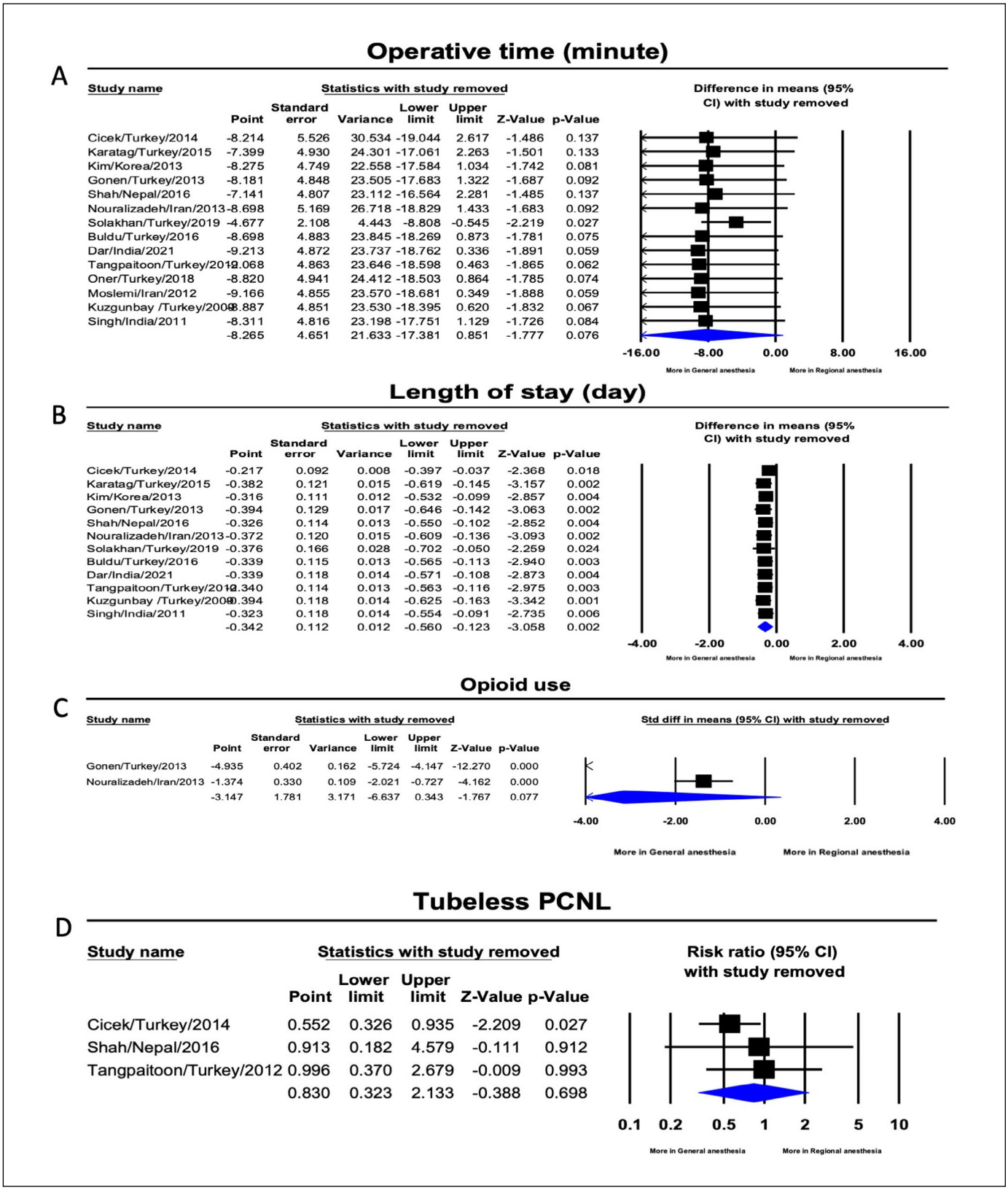


Figure 6. *Forest plots for the sensitivity analysis by the "one-study-removed" procedure comparing the outcomes of percutaneous nephrolithotomy patients between regional anesthesia and general anesthesia groups:* **(a)** *Operative time,* **(b)** *Length of stay,* **(c)** *Opioid use,* **(d)** *Tubeless percutaneous nephrolithotomy.*

PCNL – percutaneous nephrolithotomy

p = 0.041), a higher BMI (MD = 0.9, 95% CI 0.51 to 1.29, p <0.001), a shorter length of stay (MD = -0.34 days, 95% CI -0.56 to -0.12, p = 0.002), lower nephrostomy rates (RR = 0.61, 95% CI 0.5 to 0.7, p <0.001), lower postoperative nausea and vomiting rates (RR = 0.16, 95% CI 0.03 to 0.80, p = 0.026), lower complications grade III–V rates (RR = 0.68, 95% CI 0.52 to 0.89, p = 0.006), and lower postoperative visual analogue pain score (VAS) at 1 hour (MD = -3.5, 95% CI -4.1 to -2.9, p<0.001) [9–22]. There were no significant differences in other outcomes between the two groups, including the size of the stone, stone burden, operative time, need for auxiliary procedures, stone-free rates (SFR) at 1 month, blood transfusion, complications grade I–II, postoperative visual analogue pain score at 12 hours, postoperative VAS at 24 hours and opioid use (Table 2, Figures 1–5) [23].

The heterogeneity of the operative time, length of stay, and opioid use was high (I^2 = 94%, 89%, and 94%, respectively). We used sensitivity analysis to assess the heterogeneity (Figure 6).

Risk of bias assessment

The NOS tool was used to evaluate the study's quality. Most of the included studies were retrospective (n = 8), with five randomised studies [9, 10, 13, 17, 19]. The number of stars awarded to each included study ranged from six to nine. Details of the given stars within each NOS domain are shown in Table 3.

Publication bias

We used Egger's regression test to assess the publication bias, and it did not suggest any evidence of bias, as confirmed by Egger's regression test (p = 0.896). Moreover, the funnel plot showed no evidence of asymmetry (Figure 7).

DISCUSSION

In the minimally invasive therapy era, urologists have made great efforts in modifying the technique to increase the safety, efficacy, and outcomes of PCNL. Previous meta-analyses have been per-

Table 3. *Quality assessment for the included studies*

Author/country/year	Selection				Comparability of cohorts		Outcome			Total
	Representative of the exposed cohort	Selection of external control	Ascertainment of exposure	Outcome of interest not present at the start of the study	Main factor	Additional factor	Assessement of outcomes	Sufficient follow-up time	Adequecy of follow-up	
Singh/India/2011 [9]	*	*	*	*	*	*	*	*	0	8
Kuzgunbay /Turkey/2009 [10]	*	*	*	*	*	*	*	*	0	8
Moslemi/Iran/2012 [11]	*	0	*	*	*	0	*	*	0	6
Oner/Turkey/2018 [12]	*	0	*	*	*	0	*	*	0	6
Tangpaitoon/Turkey/2012 [13]	*	*	*	*	*	*	*	*	0	8
Dar/India/2021 [14]	*	*	*	*	*	*	*	*	*	9
Buldu/Turkey/2016 [15]	0	*	*	*	*	*	*	*	0	7
Solakhan/Turkey/2019 [16]	*	*	*	*	*	*	*	*	0	8
Nouralizadeh/Iran/2013 [17]	*	*	*	*	*	*	*	*	0	8
Gonen/Turkey/2013 [18]	*	0	*	*	*	*	*	*	*	8
Shah/Nepal/2016 [19]	*	*	*	*	*	*	*	*	0	8
Kim/Korea/2013 [20]	*	0	*	*	*	0	*	*	0	6
Cicek/Turkey/2014 [21]	*	*	*	*	*	0	*	*	0	7
Karatag/Turkey/2015 [22]	0	*	*	*	*	*	*	*	0	7

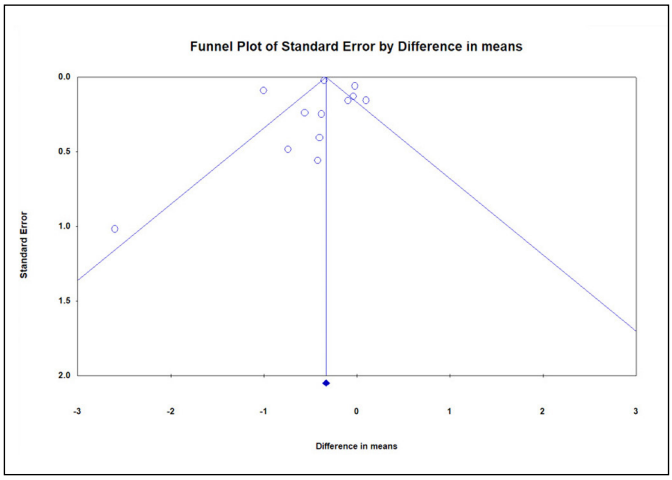


Figure 7. *Funnel plot shows no evidence of asymmetry which was further confirmed by the Egger's regression test (p = 0.896).*

formed to evaluate the impact of different anaesthesia modalities on PCNL outcomes [24–26]. However, in the last four years, there have been some new studies with larger data published as well as changes in clinical practice, our recent meta-analysis could provide updated evidence and evaluate the current outcomes.

Firstly, our recent study found that the patients undergoing regional anaesthesia had a significantly higher age and BMI compared to those under general anaesthesia [16, 20, 22]. This finding indicated a difference between these two approaches in patient selection, which is an important factor to consider. Regional anaesthesia is an optimal option in patients with higher age and BMI, who have a higher risk of respiratory and cardiovascular events, and anaesthesia-related complications.

Secondly, our results found that regional anaesthesia had a lower postoperative nausea and vomiting rate and a lower immediate postoperative visual analog pain score [13, 14, 19]. Although these two approaches had no significant difference in postoperative visual analog pain score at 12 hours and 24 hours, these findings indicate the advantages of regional anaesthesia compared to general anaesthesia in PCNL. These results are consistent with a previous meta-analysis [25]. In our study, we also found that the regional anaesthesia group had a shorter stay length than the general anaesthesia group [27]. In addition, regional anaesthesia patients also offer a lower cost of anaesthesia and better health-economic benefits [28].

Thirdly, regarding surgical outcomes, the regional anaesthesia group had a lower nephrostomy rate and lower complications grade III–IV rates with the same size of stone and stone burden, and the similar efficacy in operative time, blood transfusion, complication grade I–II, need for the auxiliary procedure, and SFR at 1 month [13, 21].

Overall, our study highlights some advantages of regional anaesthesia compared to general anaesthesia, such as lower postoperative nausea and vomiting rates, lower complication grade III–IV rates, and a shorter length of stay. Furthermore, patient selection plays an important role when choosing anaesthesia techniques, which depends on individual patient characteristics and possibly patient counselling.

The meta-analysis study design of this study has some inherent limitations. The included studies used various regional anaesthesia approaches, puncture types, sheath sizes, and lithotriptor types, resulting in heterogeneity. Furthermore, the short-term follow-up of the published studies limits the comparison of long-term outcomes, although this may be a minor concern as early outcomes should be validated before comparing longer-term results with new approaches. Finally, the regional anaesthesia group used different anaesthesia levels in the included studies. Despite these limitations, this study is the most comprehensive meta-analysis of the subject; It provides health systems and surgeons with insights into the potential benefits of regional anaesthesia in PCNL.

CONCLUSIONS

Our results show that PCNL under regional anaesthesia is safe and feasible, with comparable results to those under general anaesthesia. While the results are similar, PCNL under regional anaesthesia had a reduced rate of postoperative nausea and vomiting, immediate post-operative pain, major complications, and length of hospital stay. While patient selection is important, counselling and decision-making for these procedures must go hand in hand to achieve the best clinical outcomes.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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