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REVIEW

Operative and nonoperative management for renal trauma: comparison of outcomes. A systematic review and meta-analysis

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Introduction: Preservation of kidney and renal function is the goal of nonoperative management (NOM) of renal trauma (RT). The advantages of NOM for minor blunt RT have already been clearly described, but its value for major blunt and penetrating RT is still under debate. We present a systematic review and meta-analysis on NOM for RT, which was compared with the operative management (OM) with respect to mortality, morbidity, and length of hospital stay (LOS).

Methods: The Preferred Reporting Items for Systematic Reviews and Meta-analyses statement was followed for this study. A systematic search was performed on Embase, Medline, Cochrane, and PubMed for studies published up to December 2015, without language restrictions, which compared NOM versus OM for renal injuries.

Results: Twenty nonrandomized retrospective cohort studies comprising 13,824 patients with blunt (2,998) or penetrating (10,826) RT were identified. When all RT were considered (American Association for the Surgery of Trauma grades 1–5), NOM was associated with lower mortality and morbidity rates compared to OM (8.3% vs 17.1%, odds ratio [OR] 0.471; 95% confidence interval [CI] 0.404–0.548; $P<0.001$ and 2% vs 53.3%, OR 0.0484; 95% CI 0.0279–0.0839, $P<0.001$). Likewise, NOM represented the gold standard treatment resulting in a lower mortality rate compared to OM even when only high-grade RT was considered (9.1% vs 17.9%, OR 0.332; 95% CI 0.155–0.708; $P=0.004$), be they blunt (4.1% vs 8.1%, OR 0.275; 95% CI 0.0957–0.788; $P=0.016$) or penetrating (9.1% vs 18.1%, OR 0.468; 95% CI 0.398–0.0552; $P<0.001$).

Conclusion: Our meta-analysis demonstrated that NOM for RT is the treatment of choice not only for AAST grades 1 and 2, but also for higher grade blunt and penetrating RT.

Keywords: renal trauma, blunt trauma, penetrating trauma, operative management, nonoperative management, systematic review, meta-analysis

Introduction

The kidney is the third most frequently injured organ in abdominal trauma after the spleen and liver.[1] In the last 30 years, the treatment strategy of renal trauma has changed from operative management (OM) to nonoperative management (NOM).[1] Several studies showed improving outcomes when NOM was applied in blunt trauma and, therefore, conservative management gained an increasing popularity among trauma surgeons.[2–4]

However, specific guidelines regarding renal trauma are still lacking and the few papers providing recommendations are not supported by relevant grades of evidence.

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Immediate surgical management of injuries with life-threatening hemorrhage is widely accepted; however, when this clear-cut indication is lacking, several differences in management strategies emerge from the literature.[5–8] A successful conservative management for blunt low-grade renal injury (renal contusions and minor lacerations) is well documented with a low complication rate,[9,10] but what about the optimal management of penetrating and high-grade blunt injuries?

We first investigated through a systematic review and meta-analysis the efficacy of OM and NOM on any grade, blunt or penetrating, renal trauma and evaluated mortality, morbidity, and length of hospital stay (LOS) for the different types of injuries and management.

Methods

Study selection

The criteria of the "Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement" were followed in the present study.[11] Embase, Medline, Cochrane, and PubMed databases were used to identify studies, published up to December 2015, comparing blunt and penetrating renal trauma in adults. The following MESH search headings were used: "operative and non-operative management renal trauma", "operative and non-operative treatment for blunt and penetrating adult renal injury", "operative and non-operative treatment for genitourinary trauma", and "operative and non-operative management kidney injury". The "related articles" function in PubMed database was used to increase and widen the search to all similar abstracts and studies.

Inclusion criteria

Studies comparing the selected clinical outcomes – that is, mortality, morbidity and length of stay – of adult patients submitted to OM and NOM for renal trauma were selected for the analysis.

Exclusion criteria

We did not consider for meta-analysis: 1) studies in which mortality, morbidity, and LOS were not reported separately for NOM and OM, 2) studies analyzing pediatric patients, or 3) papers reporting series already selected for this meta-analysis.

Data extraction

Data concerning study author, year of publication, patient characteristics, study design, number of patients submitted to NOM or OM, mortality rates, morbidity rates, and length of stay (LOS) were extracted and inserted into a database.

Outcomes of interest and definition

Patients' demographics (age and sex), trauma characteristics (open or blunt), trauma severity (Injury Severity Score – ISS), American Association for the Surgery of Trauma (AAST) grade, hemodynamic stability, type of management (operative and nonoperative), and clinical outcomes (morbidity, mortality, LOS) were retrieved.

Morbidity and mortality were defined as in-hospital complication and mortality rates.

Intervention types were defined as: NOM (clinical observation, medical treatment, and proximal or distal renal angio-embolization) and OM (total or partial nephrectomy, nephrorrhaphy, or application of hemostatic agents).

Study endpoints

The primary endpoint was the overall mortality and morbidity defined as any death or complication that occurred after the start of NOM or OM and during the hospital stay for all renal trauma (blunt and penetrating).

The secondary endpoint was the overall mortality and morbidity that occurred after the start of NOM or OM and during the hospital stay for blunt and penetrating renal trauma considered separately.

The tertiary endpoint was the overall mortality and morbidity that occurred after the start of NOM or OM and during the hospital stay for all high-grade renal trauma (AAST 3–5).

The quaternary endpoint was the length of stay after the start of NOM or OM.

Study selection

A total of 465 papers were identified at the end of the literature search. After a first evaluation performed by abstract analysis, 369 studies were excluded because they were irrelevant to the purpose of our study, and 37 studies because of overlapping data. The full-text analysis of the 49 remaining studies resulted in exclusion of 29 because they did not match the inclusion criteria, while 20 were selected for further analysis.[5,12–30]

Search strategy results

Twenty nonrandomized retrospective cohort studies (Table 1) accounting for a total of 13,824 patients affected with renal injury form the basis of our analysis; 11,426 patients underwent NOM and 2,398 OM.

Quality of included studies

The quality of included studies was assessed by two authors (MLT and AM) using the Newcastle–Ottawa Scale (NOS).[31]

Table 1 Study selection

Reference	Type of study	Patients (N)
McGuire et al[5]	Retrospective	117
Sugihara et al[12]	Retrospective	1,505
Yang et al[13]	Retrospective	73
Sahin et al[14]	Retrospective	135
Hammer and Santucci[15]	Retrospective	51
Buckley and McAninch[16]	Retrospective	43
Kansas et al[17]	Retrospective	206
Moolman et al[18]	Retrospective	92
McClung et al[19]	Retrospective	9,584
Aragona et al[20]	Retrospective	45
van der Vlies et al[21]	Retrospective	186
Gourgiotis et al[22]	Retrospective	28
Starnes et al[23]	Retrospective	889
Bjurlin et al[24]	Retrospective	97
Shariat et al[25]	Retrospective	77
Menaker et al[26]	Retrospective	434
Raheem et al[27]	Retrospective	25
Sangthong et al[28]	Retrospective	517
Shoobridge et al[29]	Retrospective	338
Bozeman et al[30]	Retrospective	26

All included studies had good methodological quality (>5 points; mean 6.9 points, range 6–9).

Risk of bias

Distribution of age, sex, and ISS were homogenous between the NOM and OM groups. Conversely, the AAST grade was not homogenous between the two groups: in the NOM group, there were 3,252 (28.5%) high-grade (AAST 3–5) renal trauma whereas in the OM group they were 1,387 (57.8%; $P<0.0001$).

Statistical analysis

Statistical analysis was conducted using MedCalc for Windows, version 10.2.0.0 (MedCalc Software, MariaKerke, Belgium).

Odds ratio (OR), for dichotomous outcomes, was calculated by the Mantel–Haenszel method, while standardized mean difference (SMD), for continuous outcomes, was calculated by Hedges *g* statistic. Results from the meta-analysis for OR were considered statistically significant ($P<0.05$) if the value 1 was not within the 95% CI, whereas for SMD, it was if the value 0 was not within the 95% CI.

Heterogeneity was also studied by calculating the Chi^2 and the inconsistency (I^2). As I^2 detected the absence of homogeneity (>50%), the fixed effect model could not be used; therefore, the random effect model was used for analysis.

If the test of heterogeneity was statistically significant ($P<0.05$), then more emphasis should be placed on the random effects model.

Results

Twenty retrospective cohort studies comprising 13,824 patients were selected (Table 1). Eight studies analyzed 2,998 patients with blunt renal trauma (BRT),[5,12,23,26–30] whereas 12 studies analyzed the remaining 10,826 patients with penetrating renal trauma (PRT).[14–24,28] Patient characteristics are summarized in Table 2.

NOM was the most frequent and prevalent strategy adopted for renal trauma, with 11,426 (82.4%) patients treated conservatively versus 2,398 (17.3%) patients treated operatively (Table 3).

NOM was significantly more frequently adopted in BRT, compared to PRT (Table 3; $P<0.0001$). Table 4 shows the distribution of NOM and OM according to the severity of renal trauma (AAST scale), both for penetrating or blunt trauma. A significantly higher number of patients was treated conservatively for low-grade trauma and a significantly higher number of patients was treated operatively for high-grade trauma ($P<0.0001$).

Further analysis pursued the following criteria: 1) An analysis concerning all renal trauma (AAST low and high grades) and 2) an analysis concerning only high-grade renal trauma.

NOM versus OM for all renal trauma

Eleven studies compared morbidity,[5,12,15,18,22–25,27,29,30] twelve compared mortality,[12,13,15,17–19,22,26–30] and four compared LOS,[19,26,28,30] according to OM and NOM.

A higher mortality rate for OM (17.1%, 274/1,598) compared to NOM (8.3% 887/10,642; OR 0.471; 95%

Table 2 Patient characteristics

Characteristics	N=13,824
Mean age (years)	32.7
NOM	31.9
OM	32.15
Type of trauma (%)	
Blunt	2,998 (21.7)
Penetrating	10,826 (78.3)
NOM (%)	11,426 (82.7)
OM (%)	2,398 (17.3)
High-grade renal trauma (%) (AAST 3–5)	11,271 (81.5)
Low-grade renal trauma (%) (AAST 1–2)	2,553 (18.5)
Mean ISS	23.4
NOM	21.7
OM	25.7
Mean overall morbidity (%)	32.7
Mean overall mortality (%)	13.5
Mean overall LOS (days)	12.5

Abbreviations: NOM, nonoperative management; OM, operative management; AAST, American Association for the Surgery of Trauma; ISS, injury severity score; LOS, length of stay.

Table 3 Chi-square test analyzing the proportion of patients treated with NOM and OM

	NOM	OM	*P*-value
Penetrating trauma	8,653 (75.7%)	2,173 (90.6%)	<0.0001
Blunt trauma	2,773 (24.3%)	225 (9.4%)	
Total	11,426 (82.7%)	2,398 (17.3%)	

Abbreviations: NOM, nonoperative management; OM, operative management.

CI 0.404–0.548; $P<0.001$) was observed when all renal trauma were considered (Figure 1).

No statistical differences were encountered in terms of morbidity and LOS (OR 0.490; 95% CI 0.0775–3.101; $P=0.449$ and SMD =0.0407; 95% CI −0.017 to 0.099; $P=0.171$; Figures 2 and 3).

NOM versus OM for all-grade BRT

Five studies compared morbidity,[5,12,27,29,30] seven compared mortality,[12,13,26–30] and three compared LOS.[26,28,30]

We observed significantly higher morbidity and mortality rates with OM versus NOM when only blunt trauma were studied (the analysis included all grades of renal trauma according to the AAST scale; Figures 4 and 5).

After NOM, we observed a lower morbidity rate (38/1,869, 2%) when compared to OM (56/105, 53.3%) (OR 0.0484; 95% CI 0.0279–0.0839; $P<0.001$) as well as a lower mortality rate (130/2,676, 4.8%, vs 33/205, 16.1%; OR 0.445; 95% CI 0.0528–0.942; $P=0.041$).

LOS was similar between OM and NOM (SMD −0.326; 95% CI −0.802 to 0.150; $P=0.180$; Figure 6).

NOM versus OM for all-grade PRT

Six studies compared morbidity,[15,18,22–25] and five compared mortality.[15,17–19,23] No studies specifically analyzed LOS.

A significantly lower mortality rate of NOM (757/7,966, 9.5%) when compared to OM (241/1,393, 13.3%; OR 0.459; 95% CI 0.390–0.540; $P<0.001$) was recorded for all penetrating trauma (Figure 7).

Morbidity was similar for OM and NOM (OR 1.565; 95% CI 0.422–5.802; $P=0.503$; Figure 8).

Table 4 Chi-square test analyzing the proportion of patients treated with NOM and OM according to AAST scale

	AAST scale					*P*-value
	AAST 1	AAST 2	AAST 3	AAST 4	AAST 5	
Penetrating trauma						
NOM	2,652	2,680	1,653	1,013	219	<0.0001
OM	52	178	342	540	430	
Blunt trauma						
NOM	121	311	125	211	31	<0.0001
OM	0	2	8	17	50	

Abbreviations: AAST, American Association for the Surgery of Trauma; NOM, nonoperative management; OM, operative management.

NOM versus OM for high-grade (3–5) renal trauma

Seven studies compared morbidity,[15,22–25,29,30] seven compared mortality,[13,15,19,22,26,29,30] and three compared LOS.[19,26,30]

When all high-grade BRT or PRT were considered, a higher mortality rate for OM (17.9%, 790/8,658), when compared to NOM (9.1%, 229/1,276; OR 0.332; 95% CI 0.155–0.708; $P=0.004$; Figure 9), and a reduced LOS (SMD 0.0905, 95% CI 0.030–0.151, $P=0.003$) were recorded (Figure 10).

No statistical differences were observed in terms of morbidity (OR 0.733, 95% CI 0.125–4.285, $P=0.730$; Figure 11).

NOM versus OM for high-grade BRT

Two studies compared morbidity,[29,30] four compared mortality,[13,26,29,30] and two compared LOS.[26,30]

A significantly higher mortality rate for OM versus NOM (4.1%, 33/791 vs 8.1%, 5/62; OR 0.275; 95% CI 0.0957–0.788; $P=0.016$) was recorded (Figure 12).

Morbidity and LOS were similar between OM and NOM (OR 0.123; 95% CI 0.0002–73.434; $P=0.521$ and SMD −0.0880; 95% CI −0.594 to 0.418; $P=0.733$, respectively; Figures 13 and 14).

NOM versus OM for high-grade PRT

Six studies compared morbidity,[15,18,22–25] and four compared mortality.[15,18,19,22] No studies specifically analyzed LOS.

A significantly higher mortality rate of OM versus NOM (9.1%, 757/7,914 vs 18.1%, 224/1,239; OR 0.468; 95% CI 0.398–0.552; $P<0.001$) was observed (Figure 15).

No statistical differences were observed in terms of morbidity (OR 1.565; 95% CI 0.422–5.802; $P=0.503$) between the two groups (Figure 16).

Discussion

The kidney is the third most commonly injured solid organ after blunt trauma, and the second most commonly affected after penetrating trauma.[1] Every year, 245,000 renal trauma cases occur worldwide, with blunt trauma representing approximately 80% of cases.[1]

The treatment strategy of BRT has not changed in the last 30 years. The standard of care is, in most cases, nonoperative and up to 95% of the pediatric patients do not undergo surgery.[1–4,9] Conversely, the management of penetrating injuries has significantly changed.[29,30] Traditionally, penetrating renal injuries were managed with exploration, nephrorrhaphy, partial nephrectomy, or nephrectomy.[17,18]

Reference	NOM	OM	OR	95% CI	*P*-value
Moolman et al[18]	0/47	0/25	–		
McClung et al[19]	757/7,815	219/1,187	0.474	0.402–0.559	
Gourgiotis et al[22]	0/5	3/23	0.532	0.0238–11.92	
Kansas et al[17]	0/52	17/154	0.0748	0.0044–1.267	
Hammer and Santucci[15]	0/47	2/4	0.0105	0.0003–0.283	
Yang et al[13]	3/66	1/7	0.286	0.0256–3.191	
Sugihara et al[12]	11/1,440	6/46	0.0513	0.0181–0.146	
Menaker et al[26]	30/416	4/18	0.272	0.0843–0.878	
Raheem et al[27]	0/23	0/2	–		
Sangthong et al[28]	86/422	22/95	0.849	0.499–1.446	
Shoobridge et al[29]	0/295	0/25	–		
Bozeman et al[30]	0/14	0/12	–		
Total (fixed effects)	887/10,642	274/1,598	0.471	0.404–0.548	<0.001
Total (random effects)	887/10,642	274/1,598	0.255	0.121–0.537	<0.001
Test for heterogeneity: Q=29.8205, P=0.0001					

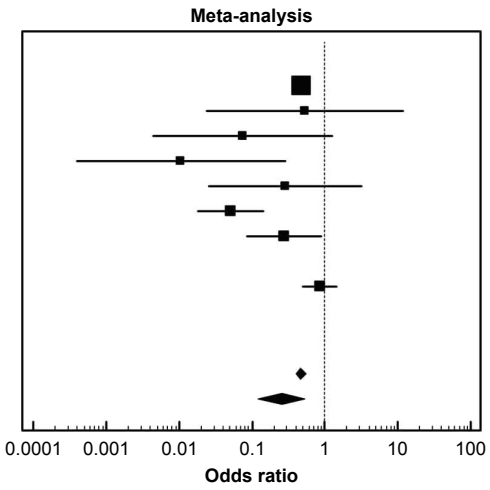

Figure 1 Overall mortality.
Note: The OR was not calculated when the results at the univariate analysis were not statistically significant: this is represented with "–" and consequently there is no 95% CI.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

The approach to renal gunshot wounds was still more prudent and careful, with surgical exploration and repair considered mandatory treatment. In 1997, Wessells et al suggested that many grade 2 penetrating renal injuries can be managed nonoperatively.[32] In 1998, Velmahos et al reported that a kidney exploration was not necessary in approximately 40% of renal gunshot trauma.[33] In 2006, the same authors showed that a nonoperative management was successful in 50% of isolated penetrating kidney injuries.[34]

In our meta-analysis, we demonstrated that NOM was the most frequent and prevalent strategy of cure used for renal trauma in adults, with 11,426 (82.4%) patients conservatively treated (17.3%) versus 2,398 patients who underwent surgery. However, when we analyzed the distribution of NOM and OM on the basis of the severity of renal trauma (AAST scale), we observed a significantly higher number of patients with low-grade trauma treated conservatively and a significantly higher number of patients with high-grade trauma treated operatively ($P<0.0001$). Furthermore, NOM was more frequently used in BRT, compared to PRT ($P<0.0001$).

Major debate concerns the indications for surgical exploration – both for BRT and PRT in high-grade trauma. The experience translated from NOM in pediatric hepatic and splenic trauma, the availability of multi-slice computerized tomography, and the acquisition of angiographic embolization techniques demonstrated that, NOM in selected hepatic and splenic high-grade trauma, also in adults, has better outcomes in terms of morbidity, mortality, and LOS when compared to surgical exploration.[34–37] In the present study, we clearly demonstrated that NOM can be safely performed even for high-grade RT, allowing a significant reduction

Reference	NOM	OM	OR	95% CI	*P*-value
Moolman et al[18]	4/47	1/25	2.233	0.236–21.130	
Gourgiotis et al[22]	5/5	10/23	14.143	0.700–285.58	
Starnes et al[23]	11/361	47/528	0.322	0.164–0.629	
Bjurlin et al[24]	2/39	1/58	3.081	0.270–35.205	
Shariat et al[25]	13/45	4/32	2.844	0.831–9.730	
Hammer and Santucci[15]	2/47	0/4	0.495	0.0204–11.977	
Sugihara et al[12]	23/1,440	43/46	0.0011	0.0003–0.0039	
Raheem et al[27]	3/23	0/2	0.854	0.0334–21.821	
Shoobridge et al[29]	2/295	12/25	0.0073	0.0015–0.0365	
Bozeman et al[30]	1/14	0/12	2.778	0.103–74.700	
McGuire et al[5]	9/97	1/20	1.943	0.232–16.265	
Total (fixed effects)	75/2,413	119/775	0.246	0.178–0.340	<0.001
Total (random effects)	75/2,413	119/775	0.490	0.0775–3.101	0.449
Test for heterogeneity: Q=127.8587, P<0.0001					

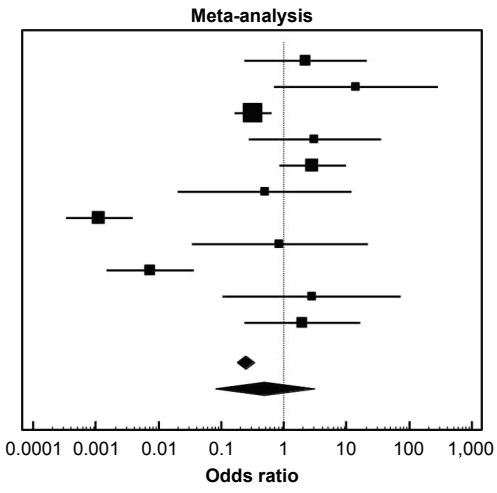

Figure 2 Overall morbidity.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

Reference	NOM	OM	Total	SMD	95% CI	*P*-value
McClung et al[19]	7,815	1,187	9,002	0.0955	0.034–0.157	
Menaker et al[26]	416	18	434	–0.276	–0.749–0.196	
Sangthong et al[28]	422	95	517	–0.657	–0.883– –0.43	
Bozeman et al[30]	14	12	26	0.264	–0.526–1.054	
Total (fixed effects)	8,667	1,312	9,979	0.0407	–0.017–0.099	0.171
Total (random effects)	8,667	1,312	9,979	–0.176	–0.670–0.318	0.484

Test for heterogeneity: Q=41.8273, P<0.0001

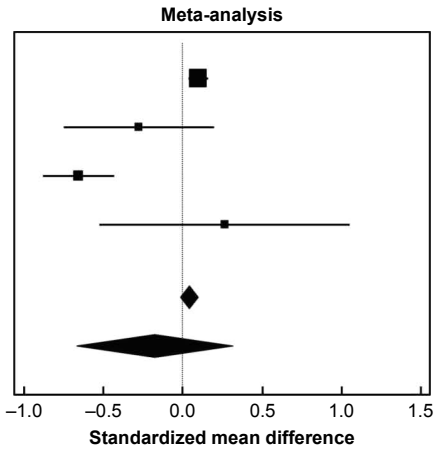

Figure 3 Overall length of stay.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; SMD, standardized mean difference.

of the mortality rate (9.1% vs 17.9%; OR 0.332; 95% CI 0.155–0.708; P=0.004; Figure 9).

When blunt and penetrating high-grade RT data were analyzed separately, we found similar outcomes: mortality in blunt trauma decreased from 8.1% after OM to 4.1% after NOM (OR 0.275; 95% CI 0.0957–0.788; P=0.016), and in penetrating trauma from 18.1% after OM to 9.1% after NOM (OR 0.468; 95% CI 0.398–0.552; P<0.001).

Our data demonstrated that hemodynamically stable patients do not always need surgical exploration, because major renal trauma may heal either spontaneously or after minimally invasive procedures. Matthews et al reported spontaneous healing in 87% of 31 patients affected with a renal injury and urinary extravasation.[38] Haas et al described a high renal salvage rate using ureteral stents in patients with renal trauma and urinary extravasation.[39] In a series of 20 patients with either grade 4 or 5 renal trauma who were conservatively treated, Moudouni et al reported six open delayed procedures, whereas the remaining patients healed spontaneously or after ureteral stent positioning.[40] Altman et al compared two groups of patients affected with grade 5 injuries.[7] Six were managed conservatively and seven were operated on. The authors affirmed that patients treated conservatively had a lower morbidity rate, with functioning renal parenchyma at follow-up CT scan.[7]

Moreover, our analysis showed a lower LOS of NOM versus OM and similar morbidity rates of both NOM and OM in patients with BRT or penetrating high-grade renal trauma, suggesting that NOM can be safely undertaken, avoiding laparotomies, kidney resections, and nephrectomies, and allowing hospital cost reduction.

Conclusion

The results of this meta-analysis showed that not only is NOM the treatment of choice for low-grade RT, but also that it should be considered as the first-line treatment

Reference	NOM	OM	OR	95% CI	*P*-value
Sugihara et al[12]	23/1,440	43/46	0.00113	0.0003–0.0039	
Raheem et al[27]	3/23	0/2	0.854	0.033–21.821	
Shoobridge et al[29]	2/295	12/25	0.00739	0.0015–0.0365	
Bozeman et al[30]	1/14	0/12	2.778	0.103–74.700	
McGuire et al[5]	9/97	1/20	1.943	0.232–16.265	
Total (fixed effects)	38/1,869	56/105	0.0484	0.0279–0.0839	<0.001
Total (random effects)	38/1,869	56/105	0.111	0.00327–3.794	0.223

Test for heterogeneity: Q=60.9339, P=ns

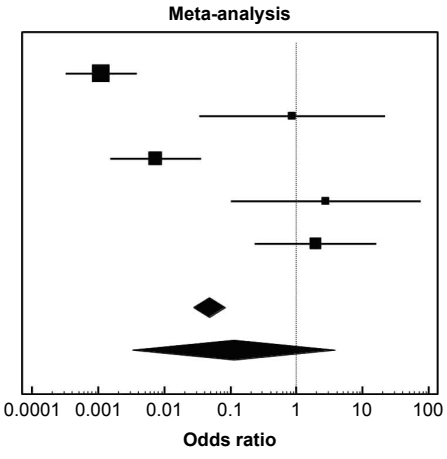

Figure 4 Morbidity for blunt renal trauma.
Abbreviations: CI, confidence interval; NOM, nonoperative management; ns, not significant; OM, operative management; OR, odds ratio.

Reference	NOM	OM	OR	95% CI	*P*-value
Yang et al[13]	3/66	1/7	0.286	0.0256–3.191	
Sugihara et al[12]	11/1,440	6/46	0.0513	0.0181–0.146	
Menaker et al[26]	30/416	4/18	0.272	0.0843–0.878	
Raheem et al[27]	0/23	0/2	–		
Sangthong et al[28]	86/422	22/95	0.849	0.499–1.446	
Shoobridge et al[29]	0/295	0/25	–		
Bozeman et al[30]	0/14	0/12	–		
Total (fixed effects)	130/2,676	33/205	0.558	0.362–0.860	0.008
Total (random effects)	130/2,676	33/205	0.445	0.0528–0.942	0.041
Test for heterogeneity: Q=24.2264, P<0.0001					

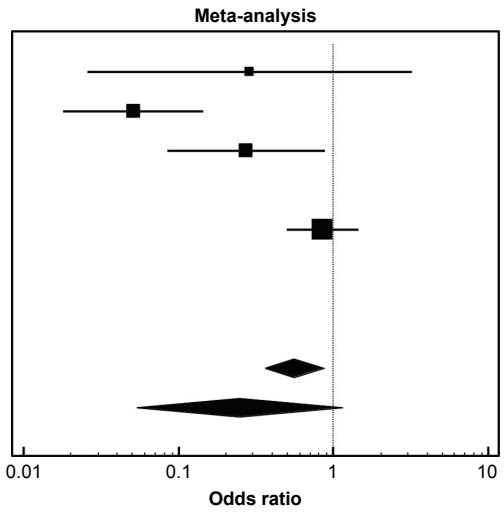

Figure 5 Mortality for blunt renal trauma.
Note: The OR was not calculated when the results at the univariate analysis were not statistically significant: this is represented with "–" and consequently there is no 95% CI.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

Reference	NOM	OM	Total	SMD	95% CI	*P*-value
Menaker et al[26]	416	18	434	–0.276	–0.749–0.196	
Sangthong et al[28]	422	95	517	–0.657	–0.883– –0.430	
Bozeman et al[30]	14	12	26	0.264	–0.526–1.054	
Total (fixed effects)	852	125	977	–0.527	–0.724– –0.331	<0.001
Total (random effects)	852	125	977	–0.326	–0.802–0.150	0.180
Test for heterogeneity: Q=6.6299, P=0.0363						

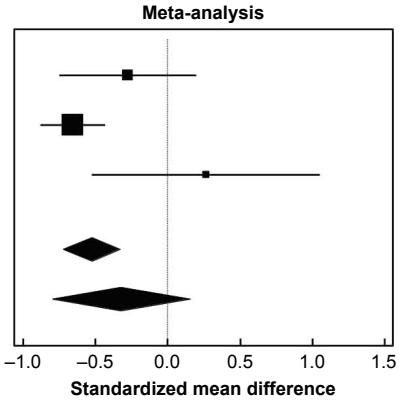

Figure 6 Length of hospital stay for blunt renal trauma.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; SMD, standardized mean difference.

Reference	NOM	OM	OR	95% CI	*P*-value
Moolman et al[18]	0/47	0/25	–		
McClung et al[19]	757/7,815	219/1,187	0.474	0.402–0.559	
Gourgiotis et al[22]	0/5	3/23	0.532	0.0238–11.92	
Kansas et al[17]	0/52	17/154	0.0748	0.0044–1.267	
Hammer and Santucci[15]	0/47	2/4	0.0105	0.0003–0.283	
Total (fixed effects)	757/7,966	241/1,393	0.459	0.390–0.540	<0.001
Total (random effects)	757/7,966	241/1,393	0.180	0.0342–0.946	0.043
Test for heterogeneity: Q=6.7917, P=0.0788					

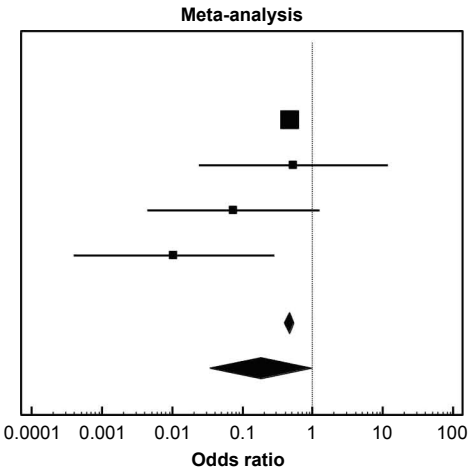

Figure 7 Mortality for penetrating renal trauma.
Note: The OR was not calculated when the results at the univariate analysis were not statistically significant: this is represented with "–" and consequently there is no 95% CI.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

Reference	NOM	OM	OR	95% CI	*P*-value
Moolman et al[18]	4/47	1/25	2.233	0.236–21.130	
Gourgiotis et al[22]	5/5	10/23	14.143	0.700–285.58	
Starnes et al[23]	11/361	47/528	0.322	0.164–0.62	
Bjurlin et al[24]	2/39	1/58	3.081	0.270–35.205	
Shariat et al[25]	13/45	4/32	2.844	0.831–9.730	
Hammer and Santucci[15]	2/47	0/4	0.495	0.020–11.977	
Total (fixed effects)	37/544	63/670	0.730	0.461–1.157	0.180
Total (random effects)	37/544	63/670	1.565	0.422–5.802	0.503
Test for heterogeneity: *Q*=16.5166, *P*=0.0055					

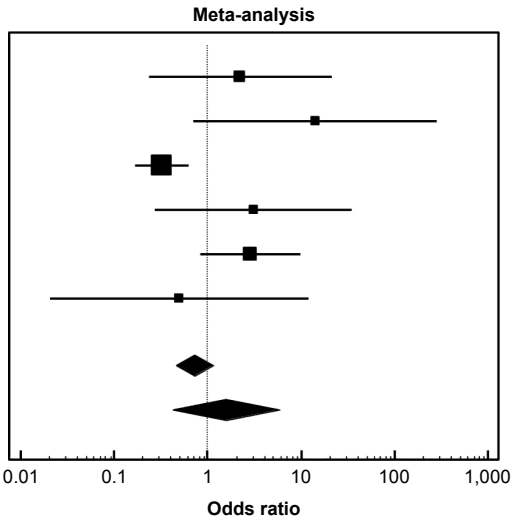

Figure 8 Morbidity for penetrating renal trauma.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

Reference	NOM	OM	OR	95% CI	*P*-value
McClung et al[19]	757/7,815	219/1,187	0.474	0.402–0.559	
Gourgiotis et al[22]	0/5	3/23	0.532	0.0238–11.928	
Hammer and Santucci[15]	0/47	2/4	0.0105	0.00039–0.283	
Yang et al[13]	3/66	1/7	0.286	0.0256–3.191	
Menaker et al[26]	30/416	4/18	0.272	0.0843–0.878	
Shoobridge et al[29]	0/295	0/25	–		
Bozeman et al[30]	0/14	0/12	–		
Total (fixed effects)	790/8,658	229/1,276	0.464	0.394–0.545	<0.001
Total (random effects)	790/8,658	229/1,276	0.332	0.155–0.708	0.004
Test for heterogeneity: *Q*=6.1070, *P*=0.1913					

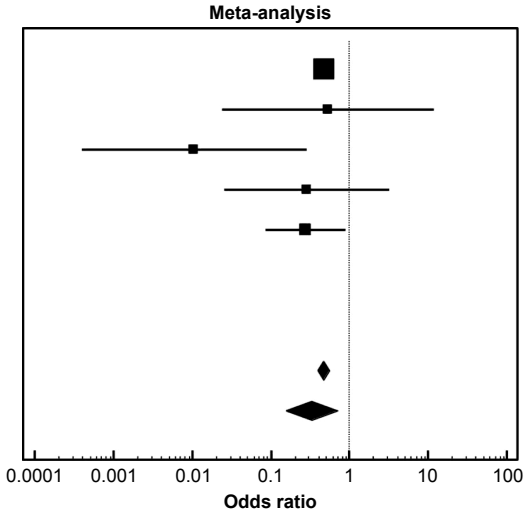

Figure 9 Overall mortality, high-grade renal trauma.
Note: The OR was not calculated when the results at the univariate analysis were not statistically significant: this is represented with "–" and consequently there is no 95% CI.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

Reference	NOM	OM	Total	SMD	95% CI	*P*-value
McClung et al[19]	7,815	1,187	9,002	0.0955	0.034–0.157	
Menaker et al[26]	416	18	434	–0.276	–0.749–0.196	
Bozeman et al[30]	14	12	26	–0.264	–0.526–1.054	
Total (fixed effects)	8,245	1,217	9,462	0.0905	0.030–0.151	0.003
Total (random effects)	8,245	1,217	9,462	0.0523	–0.145–0.249	0.603
Test for heterogeneity: *Q*=2.5597, *P*=0.2781						

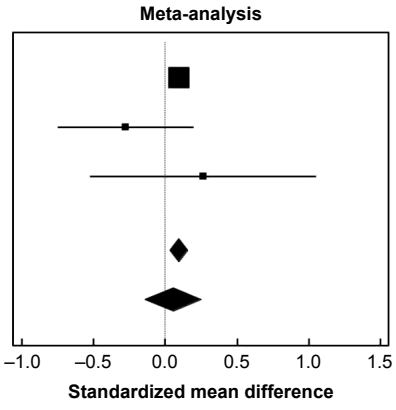

Figure 10 Overall length of stay, high-grade renal trauma.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; SMD, standardized mean difference.

Reference	NOM	OM	OR	95% CI	*P*-value
Gourgiotis et al[22]	5/5	10/23	14.143	0.700–285.58	
Starnes et al[23]	11/361	47/528	0.322	0.164–0.629	
Bjurlin et al[24]	2/39	1/58	3.081	0.270–35.205	
Shariat et al[25]	13/45	4/32	2.844	0.831–9.730	
Hammer and Santucci[15]	2/47	0/4	0.495	0.0204–11.977	
Shoobridge et al[29]	2/295	12/25	0.0073	0.0015–0.0365	
Bozeman et al[30]	1/14	0/12	2.778	0.103–74.700	
Total (fixed effects)	36/806	74/682	0.472	0.309–0.722	0.001
Total (random effects)	36/806	74/682	0.733	0.125–4.285	0.730

Test for heterogeneity: Q=43.7842, P<0.0001

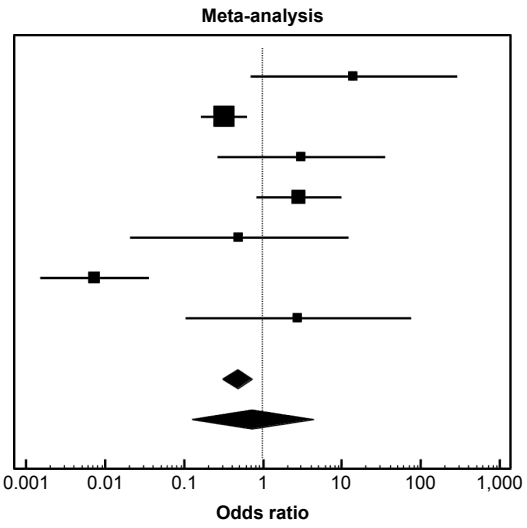

Figure 11 Overall morbidity, high-grade renal trauma.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

Reference	NOM	OM	OR	95% CI	*P*-value
Yang et al[13]	3/66	1/7	0.286	0.0256–3.191	
Menaker et al[26]	30/416	4/18	0.272	0.0843–0.878	
Shoobridge et al[29]	0/295	0/25	–		
Bozeman et al[30]	0/14	0/12	–		
Total (fixed effects)	33/791	5/62	0.275	0.0957–0.788	0.016
Total (random effects)	33/791	5/62	0.275	0.0957–0.788	0.016

Test for heterogeneity: Q=0.001288, P=0.9714

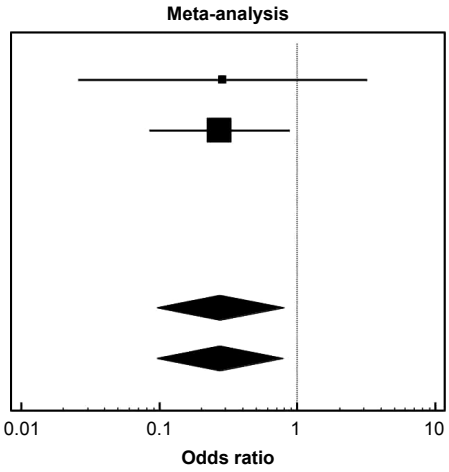

Figure 12 Mortality in high-grade blunt trauma.
Note: The OR was not calculated when the results at the univariate analysis were not statistically significant: this is represented with "–" and consequently there is no 95% CI.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

Reference	NOM	OM	OR	95% CI	*P*-value
Shoobridge et al[29]	2/295	12/25	0.0073	0.0015–0.0365	
Bozeman et al[30]	1/14	0/12	2.778	0.103–74.700	
Total (fixed effects)	3/309	12/37	0.0669	0.0192–0.233	<0.001
Total (random effects)	3/309	12/37	0.123	0.0002–73.434	0.521

Test for heterogeneity: Q=12.2296, P=0.0005

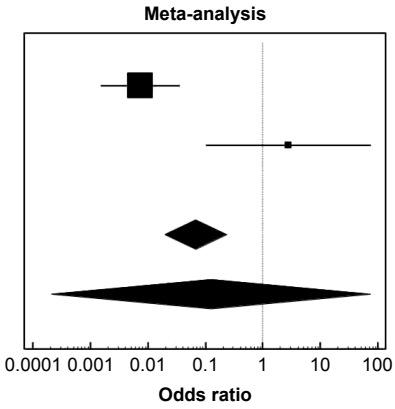

Figure 13 Morbidity in high-grade blunt trauma.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

Reference	NOM	OM	Total	SMD	95% CI	*P*-value
Menaker et al[26]	416	18	434	–0.276	–0.749–0.196	
Bozeman et al[30]	14	12	26	0.264	–0.526–1.054	
Total (fixed effects)	430	30	460	–0.123	–0.524–0.277	0.545
Total (random effects)	430	30	460	–0.0880	–0.594–0.418	0.733

Test for heterogeneity: Q=1.4309, P=0.2316

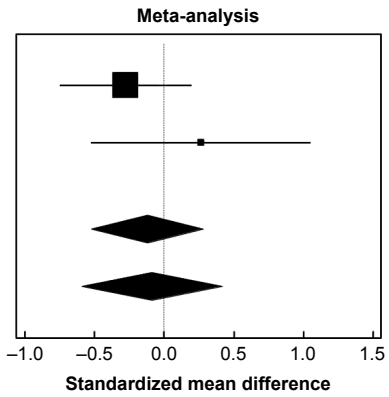

Figure 14 Length of stay in high-grade blunt trauma.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; SMD, standardized mean difference.

Reference	NOM	OM	OR	95% CI	*P*-value
Moolman et al[18]	0/47	0/25	–		
McClung et al[19]	757/7,815	219/1,187	0.474	0.402–0.559	
Gourgiotis et al[22]	0/5	3/23	0.532	0.0238–11.928	
Hammer and Santucci[15]	0/47	2/4	0.0105	0.0003–0.283	
Total (fixed effects)	757/7,914	224/1,239	0.468	0.398–0.552	<0.001
Total (random effects)	757/7,914	224/1,239	0.205	0.0259–1.628	0.134

Test for heterogeneity: Q=5.1336, P=0.0768

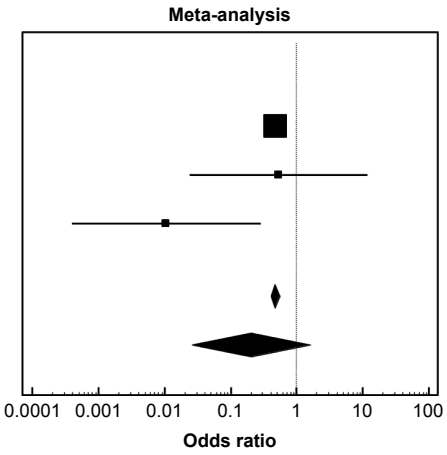

Figure 15 Mortality in high-grade penetrating trauma.
Note: The OR was not calculated when the results at the univariate analysis were not statistically significant: this is represented with "–" and consequently there is no 95% CI.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

Reference	NOM	OM	OR	95% CI	*P*-value
Moolman et al[18]	4/47	1/25	2.233	0.236–21.130	
Gourgiotis et al[22]	5/5	10/23	14.143	0.700–285.58	
Starnes et al[23]	11/361	47/528	0.322	0.164–0.62	
Bjurlin et al[24]	2/39	1/58	3.081	0.270–35.20	
Shariat et al[25]	13/45	4/32	2.844	0.831–9.73	
Hammer and Santucci[15]	2/47	0/4	0.495	0.0204–11.97	
Total (fixed effects)	37/544	63/670	0.730	0.461–1.157	0.180
Total (random effects)	37/544	63/670	1.565	0.422–5.802	0.503

Test for heterogeneity: Q=16.5166, P=0.0055

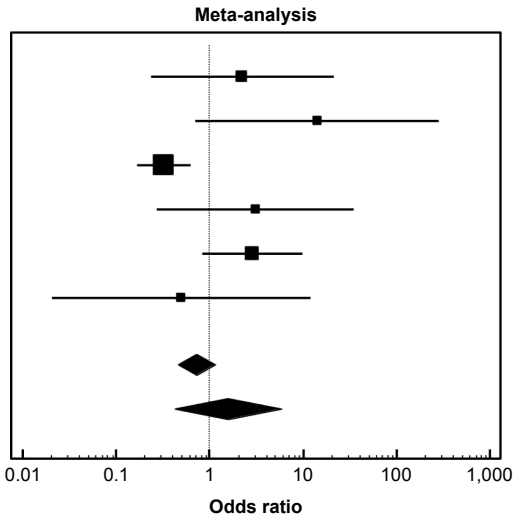

Figure 16 Morbidity in high-grade penetrating trauma.
Abbreviations: CI, confidence interval; NOM, nonoperative management; OM, operative management; OR, odds ratio.

even for high-grade blunt or penetrating RT, because it is associated to lower mortality rates and LOS, and similar morbidity rates.

Disclosure

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest in the subject matter discussed in this manuscript and report no conflicts of interest in this work.

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