Renal Disease

Impact of Hospital Volume on the Outcomes of Renal Trauma Management

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Article info

Abstract

Background: Some health care systems have set up referral trauma centers to centralize expertise to improve trauma management. There is scant and controversial evidence regarding the impact of provider's volume on the outcomes of trauma management.

Objective: To evaluate the impact of hospital volume on the outcomes of renal trauma management in a European health care system.

Design, setting, and participants: A retrospective multicenter study, including all patients admitted for renal trauma in 17 French hospitals between 2005 and 2015, was conducted.

Intervention: Nephrectomy, angioembolization, or nonoperative management.

Outcome measurements and statistical analysis: Four quartiles according to the caseload per year: low volume (eight or fewer per year), moderate volume (nine to 13 per year), high volume (14–25/yr), and very high volume ($\geq$26/yr). The primary endpoint was failure of nonoperative management defined as any interventional radiology or surgical procedure needed within the first 30 d after admission.

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Results and limitations: Of 1771 patients with renal trauma, 1704 were included. Nonoperative management was more prevalent in the very-high- and low-volume centers ($p = 0.02$). In a univariate analysis, very high hospital volume was associated with a lower risk of nonoperative management failure than low (odds ratio [OR] = 0.54; $p = 0.05$) and moderate (OR = 0.48; $p = 0.02$) hospital volume. There were fewer nephrectomies in the high- and very-high-volume groups ($p = 0.003$). In a multivariate analysis, very high volume remained associated with a lower risk of nonoperative management failure than low (OR = 0.48; $p = 0.04$) and moderate (OR = 0.42; $p = 0.01$) volume. Study limitations include all the shortcomings inherent to its retrospective multicenter design.

Conclusions: In this multicenter study, management of renal trauma varied according to hospital volume. There were lower rates of nephrectomy and failure of nonoperative management in very-high-volume centers. These results raise the question of centralizing the management of renal trauma, which is currently not the case in our health care system.

Patient summary: In this study, management of renal trauma varied according to hospital volume. Very-high-volume centers had lower rates of nephrectomy and failure of nonoperative management.

1. Introduction

Renal trauma is the most frequent genitourinary trauma, occurring in 10% of abdominal traumas [1]. Management of renal trauma has become predominantly conservative over the past decades [2,3]. However, some complex cases require interventional and/or surgical treatments, some of which may be technically demanding and may request a specific technical platform [4–7].

Some health care systems have set up tertiary referral trauma centers with the idea to centralize expertise to improve the outcomes of trauma management [8,9]. While the hospital volume (HV)-outcome relationship has largely been demonstrated for numerous complex surgical procedures, especially in oncology [10], there is scant and controversial evidence regarding the impact of provider's volume on the outcomes of trauma management [11,12]. Only two studies have aimed to assess the impact of volume on the outcomes of renal trauma. On the one hand, in their retrospective study of all renal trauma patients between 2003 and 2013, Dagenais et al [13] showed that surgical management of renal trauma is more common in low- and medium-volume renal trauma hospitals. However, their study was based on a national administrative database with no individual patient data. On the other hand, Bjurlin et al [14] showed in their retrospective study that the management outcomes of low- and high-grade renal injury were similar in patients treated in level I centers and those treated in non–level I centers. However, their main analysis focused on the association between transfer to a level I center and the odds of nonoperative management. In addition, patients transferred to a level II or below (or undesignated) centers were excluded.

The aim of our study was to evaluate the impact of HV on the outcomes of renal trauma management in a European health care system.

2. Patients and methods

2.1. Study design

The TRAUMAFUF project was a retrospective multicenter study including all patients admitted for renal trauma in 17 French hospitals between 2005 and 2015. This research project was not funded and relied exclusively upon the commitment of French urologists in training, members of the "Association Française des Urologues en Formation" (AFUF). The exclusion criteria were iatrogenic (postbiopsy or surgical procedure) and penetrating renal trauma. For each patient, the following data were collected: demographics (age and gender), details of the trauma (mechanism, American Association of the Surgery of Trauma [AAST] grade, gross hematuria at presentation, bleeding, coexisting visceral or bone injuries, and others), and the center of care. The management data (hemoglobin level, blood transfusion, duration of bed rest, early follow-up imaging, need for embolization or surgery, etc.) were collected as well. The type of initial management was categorized as operative (upfront interventional radiology or surgical procedure) or nonoperative. The study was approved by the local ethics committee and was conducted following the principles of the Helsinki Declaration.

2.2. Renal trauma management

Standardization of trauma management was not possible because of the multicenter, retrospective study design. Computed tomography (CT) urogram, selective angioembolization, percutaneous drainage, ureteral stenting, and open surgical exploration ± nephrectomy were available at all participating centers over the study period. The decision to elect nonoperative versus operative management upon admission was left at the center's/provider's discretion and guided by international guidelines.

2.3. Hospital volume

HV was calculated for each center on a year–per-year basis. We attributed to each patient a coefficient corresponding to the number of renal traumas admitted in his/her center during the same year. This coefficient allows a comparison of patients and their management according to the activity of their center. To evaluate the impact of HV, we divided patients into four

quartiles according to the caseload per year: low volume (eight or fewer per year), moderate volume (nine to 13 per year), high volume (14–25/yr), and very high volume ($\geq$26/yr). This categorization was set arbitrarily to have four equal quartiles as described previously. An exploratory analysis was also performed with HV as a continuous variable.

2.4. Outcomes of interest

The primary endpoint was failure of nonoperative management defined as any interventional radiology or surgical procedure needed within the first 30 d after admission. The secondary outcomes of interest were readmission, nephrectomy, blood transfusion within the first 30 d, 90-d deaths, time to return of bowel function, and length of hospital stay.

2.5. Statistical analysis

Means and standard deviations were reported for continuous variables, and proportions for nominal variables. Comparisons between groups were performed using the χ^2 test for discrete variables and using the Kruskal-Wallis test for continuous variables. Logistic regression univariate and multivariate analyses were used to evaluate the predictors of nonoperative management failure. Multivariate models included covariates with a p value of <0.2 in a univariate analysis. Statistical analyses were performed using JMP version 12.0 software (SAS Institute Inc., Cary, NC, USA). All tests were two sided, with a significance level at $p < 0.05$.

3. Results

3.1. Patients' characteristics

Of 1771 patients with renal trauma, 59 patients with penetrating trauma were excluded, as well as six patients for whom the mechanism of injury was unknown, and two patients for whom no hospitalization information was available. All the remaining 1704 patients were included in the present analysis. The patient flow chart is presented in Figure 1. Patients' characteristics are presented in Table 1. The number of patients managed per year in each center varied from one to 55. Patients were significantly younger in the high- and very-high-volume groups (20.3 and 31.1 vs 35.7 and 35.4 yr in the low- and moderate-volume groups, respectively; $p < 0.0001$). Gross hematuria at presentation was also more common in the high- and very-high-volume groups (60.6% and 54.4% vs 49.8% and 49.1%

in the two other groups; $p = 0.002$). The trauma AAST grades and sides were homogeneously distributed between the four groups. The rate of coexistent solid organ injury increased with HV (41% vs 44.7% vs 46.1% vs 55%; $p = 0.0005$), and there were significantly fewer coexistent bone injuries in the high-volume group than in the other groups (36.4% vs 42.7% vs 48% vs 49.2%; $p = 0.0006$).

3.2. Practice patterns according to HV

The practice patterns according to HV are summarized in Table 2. Management of renal trauma varied significantly according to HV. Nonoperative management was significantly more common in the very-high- and low-volume centers (84.6% vs 76.9% vs 78.5% vs 81.6%; $p = 0.02$), but this difference did not reach statistical significance in the subgroup of grade 4 and 5 renal trauma ($p = 0.09$). The duration of bed rest was significantly shorter in the low- and moderate-volume groups (6 vs 6.3 vs 7.8 vs 7.7 d; $p < 0.0001$). Early follow-up imaging was used more commonly in lower-volume centers (86.1% vs 83.9% vs 73.8% vs 81%; $p = 0.0007$). Upfront selective angioembolization in case of arterial contrast extravasation was less common in the low-volume group (36.2% vs 57.4% vs 79% vs 55.6%; $p = 0.0007$).

3.3. Impact of HV on outcomes

The outcomes are shown in Table 3. There was fewer failures of nonoperative management in high- and very-high-volume centers, but this difference was not statistically significant (8.1% and 6.3% vs 11% and 12.1%; $p = 0.12$). In the univariate logistic regression analysis, very high HV was significantly associated with a lower risk of nonoperative management failure than low (odds ratio [OR] = 0.54; $p = 0.05$) and moderate (OR = 0.48; $p = 0.02$) HV. There was no other statistically significant association between HV and nonoperative management failure. In high- and very-high-volume centers, hospital stay and return of bowel function were significantly longer ($p = 0.03$ and $p < 0.0001$, respectively). The 90-d death toll was higher in the very-high-volume group (3.5% vs 1.2% vs 1.2% vs 1.4%; $p = 0.02$), but the vast majority of deaths were not due to
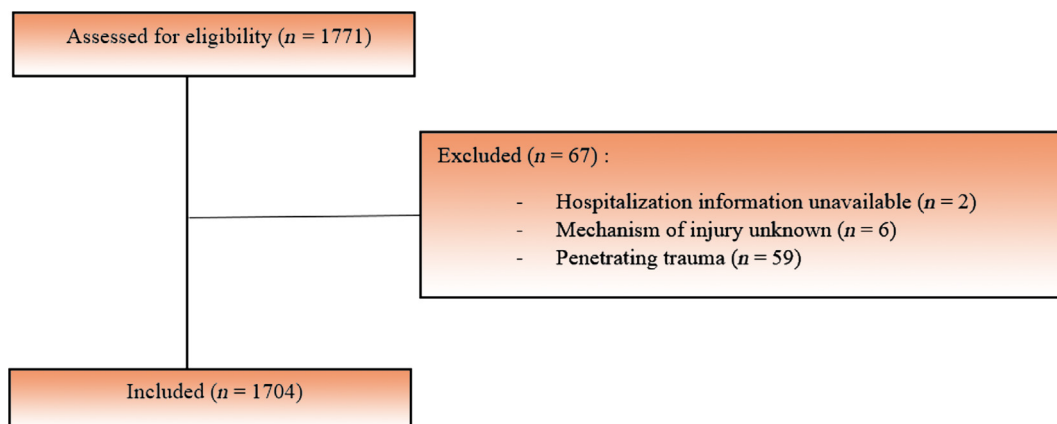

Fig. 1 – Patients' flowchart.

Table 1 – Patients' characteristics according to hospital volume

	Low (<9/yr; N = 428)	Moderate (9–13/yr; N = 424)	High (14–25/y; N = 429)	Very high (>25/yr; N = 423)	p value
Cases per year, n	5.4 (±1.96)	10.5 (±1.5)	19.3 (±3.6)	36.8 (±8.3)	<0.0001
Gender, n (%)					0.38
Male	341 (79.7)	327 (77.1)	351 (81.8)	332 (78.5)	
Female	87 (20.3)	97 (22.9)	78 (18.2)	91 (21.5)	
Mean age (yr)	35.7 (±20.4)	35.4 (±19.9)	30.3 (±17)	31.1 (±19.4)	<0.0001
Gross hematuria upon admission, n (%)	200 (49.8)	199 (49.1)	253 (60.6)	220 (54.5)	0.002
	(Missing N = 26)	(Missing N = 18)	(Missing N = 12)	(Missing N = 19)	
Initial hemodynamic instability (SBP <90 mmHg), n (%)	41 (9.8)	53 (12.7)	47 (11.2)	64 (15.5)	0.08
	(Missing N = 10)	(Missing N = 7)	(Missing N = 8)	(Missing N = 9)	
Trauma side, n (%)					0.60
Right kidney	211 (49.4)	194 (45.8)	207 (48.4)	204 (48.5)	
Left kidney	208 (48.7)	214 (50.5)	212 (49.5)	204 (48.5)	
Bilateral	8 (1.9)	16 (3.8)	9 (2.1)	13 (3.1)	
	(Missing N = 1)	(Missing N = 0)	(Missing N = 1)	(Missing N = 2)	
AAST grades, n (%)					0.26
1	99 (23.4)	94 (22.3)	94 (22.1)	92 (22.1)	
2	83 (19.6)	82 (19.5)	84 (19.7)	72 (17.3)	
3	112 (26.5)	111 (26.4)	84 (19.7)	98 (23.6)	
4	116 (27.4)	111 (26.4)	139 (32.6)	132 (31.7)	
5	13 (3.1)	23 (5.5)	25 (5.9)	22 (5.3)	
	(Missing N = 5)	(Missing N = 3)	(Missing N = 3)	(Missing N = 7)	
Coexistent bone injury	180 (42.7)	203 (48)	153 (36.4)	207 (49.2)	0.0006
	(Missing N = 6)	(Missing N = 1)	(Missing N = 9)	(Missing N = 2)	
Coexistent solid organ injury	174 (41)	189 (44.7)	196 (46.1)	232 (55)	0.0005
	(Missing N = 4)	(Missing N = 1)	(Missing N = 4)	(Missing N = 1)	

AAST = American Association of the Surgery of Trauma; SBP = systolic blood pressure.

Table 2 – Practice patterns according to hospital volume

	Low (<9/yr; N = 428)	Moderate (9–13/yr; N = 424)	High (14–25/y; N = 429)	Very high (>25/yr; N = 423)	p value
Nonoperative management, n (%)	362 (84.6)	326 (76.9)	336 (78.5)	345 (81.6)	0.02
Nonoperative management for AAST grade 4 or 5 renal trauma, n (%)	85 (65.9)	71 (53)	100 (61)	102 (66.2)	0.09
Upfront ureteral stenting, n (%)	15 (3.6)	21 (5)	29 (6.8)	24 (5.7)	0.20
	(Missing N = 6)	(Missing N = 1)	(Missing N = 2)	(Missing N = 0)	
Duration of bed rest (d)	6 (±3.1)	6.3 (±2.9)	7.8 (±2.4)	7.7 (±2.4)	<0.0001
	(Missing N = 0)	(Missing N = 1)	(Missing N = 2)	(Missing N = 1)	
Early follow-up imaging, n (%)	340 (86.1)	343 (83.9)	183 (73.8)	217 (81)	0.0007
	(Missing N = 33)	(Missing N = 15)	(Missing N = 181)	(Missing N = 155)	
Upfront selective angioembolization in case of arterial contrast extravasation, n (%)	21 (36.2)	31 (57.4)	15 (79)	20 (55.6)	0.0006

AAST = American Association of the Surgery of Trauma.

Table 3 – Outcomes according to hospital volume

	Low (<9/yr; N = 428)	Moderate (9–13/yr; N = 424)	High (14–25/y; N = 429)	Very high (>25/yr; N = 423)	p value
90-d deaths, n (%)[a]	6 (1.4)	5 (1.2)	5 (1.2)	15 (3.5)	0.02
	(Missing data N = 24)	(Missing data N = 8)	(Missing data N = 174)	(Missing data N = 149)	
Mean length of hospital stay (d)	13.5 (±13.3)	14 (±13.2)	15.3 (±28.2)	17.6 (±27.1)	0.03
	(Missing data N = 20)	(Missing data N = 9)	(Missing data N = 9)	(Missing data N = 3)	
Mean time to return of bowel function (d)	6.6 (±3.3)	6.4 (±3.4)	8.4 (±1.9)	8.2 (±2)	<0.0001
	(Missing data N = 1)	(Missing data N = 3)	(Missing data N = 3)	(Missing data N = 1)	
Readmission, n (%)	29 (7.3)	22 (5.5)	15 (5.9)	11 (4)	0.34
	(Missing data N = 33)	(Missing data N = 20)	(Missing data N = 166)	(Missing data N = 151)	
Blood transfusion, n (%)	124 (30.9)	128 (30.8)	66 (25.5)	88 (32.8)	0.28
	(Missing data N = 27)	(Missing data N = 19)	(Missing data N = 170)	(Missing data N = 155)	
Failure of nonoperative management, n (%)	31 (11)	34 (12.1)	14 (8.1)	14 (6.3)	0.12
	(Missing data N = 28)	(Missing data N = 0)	(Missing data N = 118)	(Missing data N = 80)	
Nephrectomy, n (%)	8 (1.9)	15 (3.5)	4 (0.9)	2 (0.5)	0.003

[a] Most deaths were not related to the renal trauma.

renal trauma. There were significantly fewer nephrectomies in the high- and very-high-volume groups (0.9% and 0.5% vs 1.9% and 3.5%; *p* = 0.003). HV as a continuous variable was significantly associated with reduced nephrectomy, readmission, and failure of nonoperative management rates (Supplementary Table 1).

3.4. *Predictors of nonoperative management failure*

In the multivariate analysis including covariates with a *p* value of <0.2 in the univariate analysis (ie, AAST grade, gross hematuria at presentation, and coexisting bone injury), very high volume remained significantly associated with a lower risk of nonoperative management failure than low (OR = 0.48; *p* = 0.04) and moderate (OR = 0.42; *p* = 0.01) volume. The only other significant predictive factor was AAST grade (see Table 4).

4. Discussion

The HV-outcome relationship remained poorly evaluated outside the field of surgery, especially oncologic surgery [10,15]. Some data are available in trauma management, but to date, only two studies had aimed to investigate the impact of HV on the outcomes of renal trauma management [13,14]. In this French multicenter study, we found that the management of renal trauma differed significantly according to HV and that HV had a significant impact on outcomes with lower rates of nephrectomy and failure of nonoperative management in very-high-volume (>25 renal trauma cases per year) centers. These results are consistent with those of the study by Hotaling et al [8], which concluded that conservative treatment was more frequent in level I trauma centers, although the patient population was more severely injured.

While the association between providers' volume and outcomes makes sense for surgical procedures, as the influence of increasing experience on surgeons' skills has largely been demonstrated [16], the volume-outcome connection for renal trauma is much less intuitive. Conservative management has become the mainstay in renal trauma management over the past decades [4–6], and the vast majority of patients in the present series did not require any surgical procedures, which suggest that improved surgical skills with higher volume are not the main determinant of our finding. Selective angioembolization was available at all centers over the study period. Although a higher caseload may have contributed to the improvement in selective angioembolization outcomes, this can hardly be the main driver of the volume-outcome relationship here. One may assume that several details in the global management of renal trauma patients that were not collected in our dataset, such as human and material resources available, standardized institutional protocol, and training of health care professionals, may be the key determinants of the volume-outcome relationship that we observed [17].

Conversely to most elective surgical procedures, which are planned weeks to months in advance, centralization of trauma cases poses the challenge of transferring patients who often require emergency resuscitation or surgery. Time to treatment being of utmost importance for trauma cases, lengthy prehospital transfer may outweigh the benefit of treatment in a higher-volume center [17,18]. This may explain why centralization of trauma cases has not been implemented in many health care systems, such as ours. However, in our study, we noted a difference in trauma severity according to HV. High-volume centers had a younger patient population but with more severe trauma. This would suggest that, although not officially organized at a national level, there may already be a centralization of trauma cases in our health care system. This difference

Table 4 – Predictive factors of nonoperative management failure in univariate and multivariate analysis

Variables	Nonoperative management failure							
	Univariate analysis				Multivariate analysis			
	Odds ratio	95% Confidence interval		*p* value	Odds ratio	95% Confidence interval		*p* value
		Lower	Upper			Lower	Upper	
Hospital volume								
Very high	1 [Ref]			–	1 [Ref]			–
High	1.32	0.61	2.87	0.48	1.77	0.76	4.23	0.19
Moderate	2.05	1.10	4.05	0.02	2.09	1.03	4.47	0.01
Low	1.85	0.98	3.68	0.06	2.38	1.19	5.05	0.04
Gross hematuria upon admission	1.81	1.17	2.82	0.008	1.40	0.87	2.26	0.16
AAST grade								
1	1 [Ref]				1 [Ref]			
2	4.43	1.36	19.78	0.01	3.95	1.21	17.72	0.02
3	11.21	3.92	47.22	<0.0001	9.34	3.24	39.51	<0.0001
4	20.87	7.44	87.14	<0.0001	19.33	6.82	81.15	<0.0001
5	38.30	9.08	109.58	<0.0001	36.90	7.89	103.90	<0.0001
Coexisting bone injury	1.49	0.96	2.34	0.07	0.70	0.42	1.14	0.15
Coexisting solid organ injury	1.14	0.74	1.76	0.54	–	–	–	–
Initial hemodynamic instability	1.09	0.50	2.16	0.80	–	–	–	–
Age	1.29	0.48	3.68	0.62	–	–	–	–
Gender								
Female	1 [Ref]	–	–	–	–	–	–	–
Male	1.29	0.76	2.31	0.35				

AAST = American Association of the Surgery of Trauma; Ref = reference.

in baseline patients' characteristics may explain several minor findings of the present series, such as the longer hospital stay and time to return of bowel function in high-volume centers, which could likely be underpinned by the more severe cases admitted in high- and very-high-volume centers.

Although renal trauma is a widespread and sometimes fatal disease, we observed significant heterogeneity in practice patterns of centers involved in the present study. This may be explained by the fact that the management of renal trauma has never been the subject of national guidelines in our country, which may have hampered harmonization of practices [19]. However, similar discrepancies in trauma care have already been reported in other health care systems [20]. Another hypothesis may be a decreasing interest of urologists for renal trauma care with the increasing role of nonoperative management. Finally, the lack of funding for trauma research and lack of interest of many international peer-reviewed urology journals for renal trauma may slow down the spread and permeation of evidence in the urologic community [21,22].

However, our study has several limitations that should be acknowledged. First, it has all the shortcomings inherent to its retrospective multicenter design. In the present study, patients' characteristics and management were heterogeneous, but here this can be regarded as an insightful finding rather than a real drawback. Indeed, as we have already described, the centers had heterogeneous practices. Another possible limitation is the lack of an analysis of the long-term impact of HV on renal trauma management outcomes. There was no centralized review of initial CT scans, which may have biased the grading of renal trauma. Our dataset was lacking a validated evaluation of the overall severity of injuries, such as the Injury Severity Score, which may have allowed adjusting of our analysis more accurately. The decision to split the cohort into four equal quartiles may be criticized as the volume thresholds were not set based on existing evidence of their possible impact on outcomes. Finally, our study was very "urology focused" and was lacking detailed data on human and material resources available at each center, which prevented deciphering of the determinants of the volume-outcome relationship that we observed.

5. Conclusions

In this multicenter study, management of renal trauma varied significantly according to HV with heterogeneous adoption of nonoperative management, early mobilization, and selective angioembolization. While low- and moderate-volume centers had a shorter hospital stay and time to return of bowel function, the most clinically relevant outcomes favored very-high-volume centers with lower rates of nephrectomy and failure of nonoperative management. These results raise the question of centralizing the management of renal trauma patients, which is currently not the case in our health care system. Further studies are needed to help elucidate the determinants of this possible volume-outcome relationship in renal trauma management.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.euros.2022.01.004.

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