

BMJ Open Clinical features and direct medical cost of splenic injury in China: a cross-sectional study

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ABSTRACT

Objectives This study analyses the clinical features and direct medical cost (DMC) of splenic injury during 2000–2013 in China.

Design This was a cross-sectional study.

Methods We used 'The No. 1 Military Medical Project' information system to conduct a retrospective study. Patients' information from 2000 to 2013 were identified. Demographic data, treatment, clinical data and DMC were collected. We performed a generalised linear method (GLM) using gamma distribution to assess the drivers of DMCs.

Results We included 8083 patients with splenic injury who met the study criteria. Over the 14-year study period, 2782 (34.4%) patients were treated with non-operative management (NOM), 5301 (65.6%) with OM. From 2000 to 2013, the rate of NOM increased from 34.7% to 55.9%, while OM decreased from 65.3% to 44.1%. Mean per-patient DMC in both NOM and OM increased from 2000 to 2013. In GLM analysis, male, old age, length of stay, severe splenic injury grade, OM, intensive care unit, blood transfusion and tertiary hospitals were associated with higher DMC, while female and NOM was associated with lower DMC.

Conclusions In China, management of splenic injury was the most important factor impacting the total DMC. Proper management and public policy could curtail the burden of splenic injury.

INTRODUCTION

The spleen is an organ found in all vertebrates. Similar in structure to a large lymph node, its function is to alternatively get rid of immune complexes, circulating pathogens and senescent, dysfunctional or infected red blood cell.^{1 2} Trauma is a leading cause of death, with approximately 5 million deaths reported each year globally. According to reports, splenic injuries take up to 16%–23.8% of trauma, with a mortality rate of 9.3%, mainly in response to associated injuries and treatment.³ Recently, management paradigms for splenic injury are always controversial. Although non-operative management (NOM) has been recognised as a standard of treatment in haemodynamically stable patients (an estimated success rate exceeding

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ We provided the most comprehensive description of clinical features of splenic injury and its related direct medical cost in China.
- ⇒ This study is useful for government and health administration services to reform the healthcare policies to contain trauma-related medical costs, and it provides useful evidence for management of splenic trauma in China.
- ⇒ This research cannot tell what type of non-operative management was adopted in patients due to the lack of related code in Chinese Trauma Databank.
- ⇒ The insurance types were not recorded in this database, we cannot estimate patients-related medical care utilisation or provide comprehensive cost analysis of patients with splenic injury.

80%–90%),^{3 4} some literature contends old age, high grade of splenic trauma, the sign of a large haemoperitoneum, contrast extravasation on admission, high Injury Severity Score (ISS) value, low systolic blood pressure on admission, transfusion of more than one packed cells and the presence of brain injury associated trauma may increase the probability of failure of NOM.^{5 6}

At present most of the studies on splenic injuries focused on the comparison of the safe and clinical outcomes of operative vs NOM.^{4 7} The direct medical cost (DMC) is a factor that cannot be neglected in evaluating if treatment strategies are proper from a healthcare economy point of view. The study of the cost of managing splenic injuries has rarely been reported in multicentre studies.^{8–10} Moreover, there are no data on the cost of management of splenic injuries in China, and the studies on the characteristic of splenic injuries in Chinese hospitals were rarely reported.

The issues of medical cost in China are notably complicated due to its changing public medical insurance policy features. Therefore, it is necessary to understand the association of structure of medical cost with

the different modalities of strategies, which may provide some useful data and evidence for healthcare workers and healthcare policymakers, to a certain extent.

Until now, there is no study on DMC of splenic injury. To fill the gap, we explored the related factors of the total DMC of splenic injury based on a database. These results will provide an insight into the potential factors that contribute to DMC and support useful evidence for making a public policy to reduce the burden of splenic injury.

MATERIALS AND METHODS

Data source

Data for this study were obtained from 'The No. 1 Military Medical Project' information system, which is part of the Chinese Trauma Databank (CTDB).^{11–14} It was built and maintained by the Information Centre of the Medical Department under the Ministry of General Logistics of the Chinese People's Liberation Army (PLA), possessing a lot of users' groups in China, and covering more than 200 military hospitals and 90 public hospitals. The database collects large amounts of trauma care data aiming to help the research, prevention and treatment of trauma.

Inpatients' information was included in the CTDB. Data handling in this system-based study are performed without revealing the identity of any participants and, therefore, obtaining ethical approval is not required.

Study design

This was a retrospective study using the data from the No. 1 Military Medical Project information system to identify 8038 inpatients with splenic injury (ICD9-CM 865.00–865.19) in 8 hospitals (6 tertiary, 3 army medical hospitals of the PLA in Chongqing, the fourth people's hospital of Chongqing, affiliated hospital of Chengdu medical college, NO. 324 hospital of the army, and 2 secondary hospitals, NO. 22 hospital of the army and NO. 477 hospital of the army) between January 2000 and December 2013. Patients who underwent splenectomy, splenorrhaphy and partial splenectomy were all defined as the OM group, while the others were identified as the NOM group.

Basic demographic data, DMC, the total length of hospital stay (LOS), injury pattern, trauma mechanism, transfusion, mortality, New Injury Severity Score (NISS)¹⁵ and splenic injury grade¹⁶ were collected. Exclusion criteria included patients who were dead on arrival at the hospital and those patients for whom complete data are unavailable (figure 1).

Estimation of costs

In our study, we extracted the DMC of each patient from the database, which includes medications, laboratory tests, imaging, surgery, transfusion, hospitalisation (medical consumables, diagnostic procedures, material, etc) and other costs (room costs, nursing care cost, etc). However, there were only records of total DMCs in

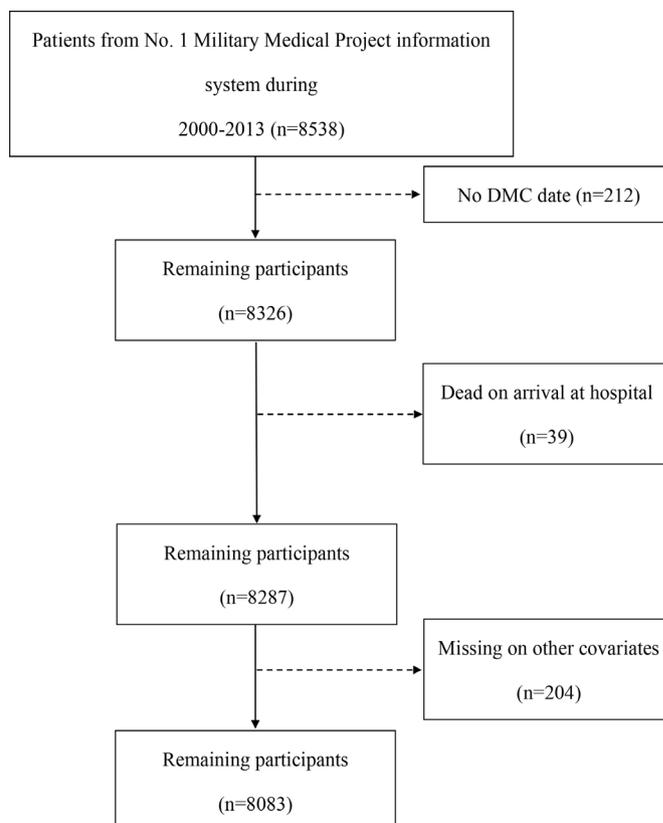


Figure 1 Flow chart of the study. DMC, direct medical cost.

2010–2013, the expenses category was missing during that period in CTDB.

The total DMC from other years (2000–2012) was first converted into 2013 values in Renminbi (RMB) adjusting for inflation,¹⁷ using the GDP deflator of China,¹⁸ and was then converted to US dollars (USD) at the exchange rate equaling US\$1=RMB6.196 for 2013.

Statistical analysis

Statistical analysis was performed using the RStudio, V.1.4.1717 (GNU General Public License) and SPSS V.22.0 (IBM). Mann-Whitney U test was applied for quantitative variables, the χ^2 test for categorical variables and the Kruskal-Wallis rank-sum test for continuous variables. Statistical significance was set at 0.05. We used the Bonferroni test for multiple corrections. Because DMC barely complies with the assumptions of the ordinary least squares regression, they, usually, are skewed to the right. Thus, a generalised linear method (GLM) with gamma family, log-link function was used to assess the factors impacting on the DMCs of splenic injury.

Patient and public involvement

No patients were involved.

RESULTS

Characteristics of patients by management

Table 1 shows the demographic and clinical characteristics of patients with splenic injury managed with NOM

Table 1 Demographic and clinical characteristics of the study population by management

	NOM n=2782	OM n=5301	P value
Male	2217 (80%)	4405 (83.1%)	<0.001
Age			<0.001
<18	324 (11.6%)	421 (7.9%)	
18–40	1630 (58.6%)	3131 (59.1%)	
41–65	754 (27.1%)	1635 (30.8%)	
>65	74 (2.7%)	114 (2.2%)	
Trauma cause			<0.001
Car collision	1046 (37.6%)	2092 (39.5%)	
Motorcycle or cycling collision	126 (4.5%)	268 (5.2%)	
Fall from heights	365 (13.3%)	811 (15.3%)	
Fall and hurt oneself	208 (7.5%)	465 (8.8%)	
Crush injury	34 (1.2%)	50 (0.9%)	
Penetrating injuries	385 (13.5%)	798 (15.1%)	
Sports	112 (4%)	157 (3%)	
Personal assault	340 (12.2%)	533 (10.1%)	
Others	166 (6%)	127 (2.4%)	
Splenic grade			<0.001
I/II	2707 (97.4%)	1280 (24.1%)	
III/IV	57 (2%)	3512 (66.3%)	
V	18 (0.6%)	509 (9.6%)	
NISS			<0.001
Mild <15	1722 (61.9%)	1666 (31.4%)	
Moderate 15–25	784 (28.2%)	2209 (41.7%)	
Severe >25	276 (9.9%)	1426 (26.9%)	
Hospital level			0.727
Secondary hospitals	569 (20.5%)	1067 (20.1%)	
Tertiary hospitals	2213 (79.5%)	4234 (79.9%)	
Blood transfusion >1	539 (19.4%)	3474 (65.5%)	<0.001
LOS, median (IQR)	11 (7–18)	14 (10–12)	<0.001
Mortality	76 (2.7%)	200 (3.8%)	<0.001
Direct medical cost, median (IQR)	1223 (595–2542)	3062 (2104–4619)	<0.001

IQR, inter quartile range; LOS, length of stay; NISS, New Injury Severity Score; NOM, non-OM; OM, operative management.

or OM. In this study, a total of 8083 patients with splenic injury from 2000 to 2013 were included. Most of the patients managed with NOM or OM were men, 80% or 83.1%, respectively. Patients in the age group 18–40 years took up most of the population in NOM and OM. Car collision was the main factor that causes splenic injury. There was no difference between secondary hospitals and tertiary hospitals adopting the treatment strategies on patients. Compared with patients in NOM, patients in OM had longer LOS, more blood transfusion, higher splenic injury grade, NISS, mortality and total DMC.

In addition, the proportion of patients with OM decreased from 65.3% in 2000 to 44.1% in 2013, while patients with NOM increased from 34.7% in 2000 to 55.9% in 2013 (figure 2A). In 2000, the mean DMC per-patient with NOM

and OM was US\$2256 and US\$3089, respectively. However, the mean DMC per-patient has risen to US\$3627 (NOM) and US\$5312 (OM), respectively, in 2013 (figure 2B).

Structure of DMC

Figure 3 has shown that the distribution of various DMC by different management. Drug cost is the main expenditure in DMC, accounting for 46% (US\$1612) of total DMC, followed by hospitalisation (18%, USD\$633). Patients with NOM and OM had similar patterns structure of DMC, but transfusion and surgery costs are higher in patients with OM than patients with NOM.

Predictors of DMC

Table 2 shows the results of GLM with gamma distribution and the log-link function performed to determine

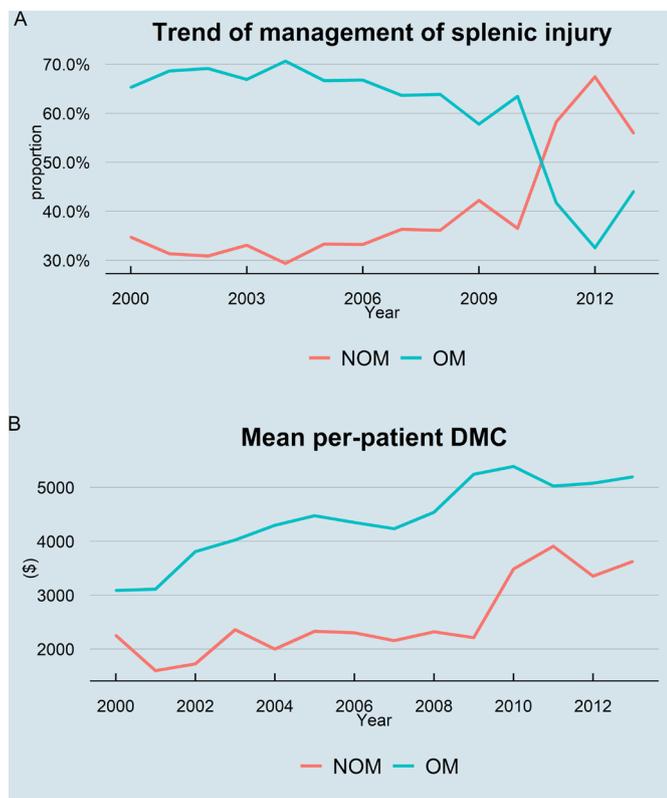


Figure 2 (A) Overall trend in splenic management over time from 2000 to 2013. (B) Mean per-patient direct medical cost from 2000 to 2013. DMC, direct medical cost; NOM, non-OM; OM, operative management.

the variables affecting DMCs. The cost of treating splenic injury in female patients was 6.3% lower compared with that of men ($p=0.002$). LOS was predicted to increase the DMC by 2.2% ($p<0.01$). The cost of patients improved after treatment was 34.6% higher compared with that of those who were dead ($p<0.001$). Patients with a high splenic injury grade, blood transfusion, OM, admission to intensive care unit, old age and high NISS (>25) from tertiary hospitals had to bear higher total DMC. While there was no significant difference between mild and moderate NISS. Compared with 2000, the mean per-patient DMC increased 2002–2013.

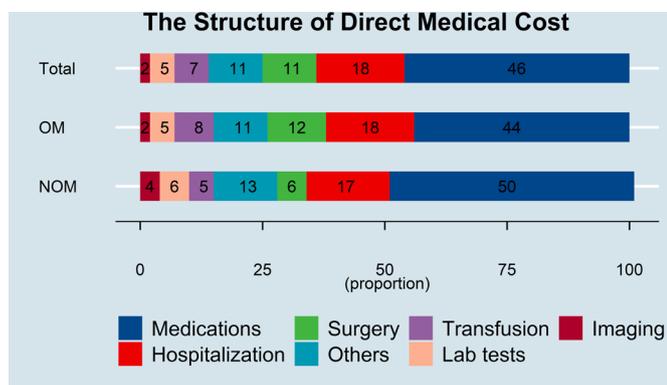


Figure 3 Direct medical cost subtypes of patients with splenic injury by management from 2000 to 2009 (percentages). NOM, non-OM; OM, operative management.

DISCUSSION

Using a large military fund database from China, we can obtain the clinical data of patients with splenic injury and calculate DMC resulting from the splenic injury. To our knowledge, this is the first description of the multicentre clinical features and DMC of splenic injury in China. Currently, NOM is the standard of treatment in haemodynamically stable patients with splenic injury, and the success rate of this produces exceeds 80%–90%.³ In this retrospective study, we showed the changes in the treatment of splenic trauma and its related DMC in China from 2000 to 2013. Interestingly, the ratio of NOM had increased gradually in Chinese hospitals, while the DMC of patients with splenic injury had increased sharply after 2010.

In this study, the rate of patients with splenic injury with OM was higher than patients with NOM before 2010, which contrasted with many studies.^{5,7,9} However, patients undergoing NOM vastly outnumbered patients with OM after 2010. We suppose there are several reasons for this phenomenon. First, before the reform of the Chinese healthcare system in 2009, the healthcare resources are seriously insufficient, and inequalities exist everywhere. Moreover, the relationship in China between doctors and patients is usually strained.¹⁹ Thus, to avoid medical conflicts whenever possible, some Chinese doctors must choose a safe and conservative treatment to improve the one-time success ratio of treatment. Second, the Chinese government has introduced a new healthcare reform since 2009. Five main domains were reformed in China's health system reform: social health security, essential medicines, primary healthcare, basic public health service package and public hospitals. These measures improved access to healthcare and reduced health inequality, to a certain extent. Moreover, it, to some degree, reduced the contradiction between doctors and patients and promoted the progress of medical level.²⁰ However, in public hospitals, medical expenditure per-patient discharged increased by 22.1% between 2010 and 2013.^{21,22} The proportion of out-of-pocket healthcare payments decreased, but the financial burden of healthcare did not fall much. The proportion of drug cost in total hospital expenditure has decreased, but total hospital expenditure is still rising.²² Thus, splenic injury patients with low splenic grade and mild NISS were more likely to be adopted by NOM, but the per-patient DMC was higher than before whatever management doctors took. Previous studies have reported that nonsurgical treatment of blunt splenic injury is cost effective due to patients undergoing OM tend to have a longer LOS, drug, caregiving, more blood transfusions and more medical consumables,^{9,23} which is similar to our results. Although the rate of patients with NOM is higher than OM in this study after 2010, the DMC of NOM in our study is much lower than OM.

China has already entered the ageing society since 1999 and is one of the fastest ageing countries in the world.²⁴ Injury is the fifth-leading cause of death in the elderly. Compared with younger patients, advanced age patients

Table 2 Results of a generalised linear model with gamma distribution

Variables	β	SE	P value	EXP (β)	95% CI
Gender					
Male	Reference			1	
Female	-0.065	0.019	0.002**	0.937	0.903 to 0.972
LOS	0.022	0.000	<0.001***	1.022	1.021 to 1.023
Mortality					
Death	Reference			1	
Alive	0.268	0.041	<0.001***	1.308	1.208 to 1.419
Splenic injury grade					
I/II	Reference			1	
III/IV	0.074	0.021	<0.001***	1.077	1.034 to 1.121
V	0.190	0.034	<0.001***	1.208	1.132 to 1.291
Management					
NOM	Reference			1	
OM	0.431	0.023	<0.001***	1.539	1.474 to 1.605
ICU					
No	Reference			1	
Yes	0.444	0.024	<0.001***	1.559	1.488 to 1.633
Blood transfusion>2					
No	Reference			1	
Yes	0.440	0.016	<0.001***	1.553	1.506 to 1.602
Age					
<18	Reference			1	
18–40	0.242	0.026	<0.001***	1.274	1.211 to 1.339
41–65	0.299	0.027	<0.001***	1.349	1.277 to 1.423
>65	0.347	0.053	<0.001***	1.414	1.275 to 1.572
NISS					
<15	Reference			1	
15–25	0.024	0.017	0.154	1.024	0.991 to 1.058
>25	0.055	0.021	0.095**	1.056	1.014 to 1.100
Hospital					
Secondary hospitals	Reference			1	
Tertiary hospitals	0.351	0.018	<0.001***	1.420	1.370 to 1.471
Year					
2000	Reference			1	
2001	0.049	0.046	0.279	1.05	0.960 to 1.148
2002	0.268	0.046	<0.001***	1.308	1.195 to 1.429
2003	0.397	0.045	<0.001***	1.488	1.360 to 1.624
2004	0.416	0.046	<0.001***	1.516	1.395 to 1.657
2005	0.474	0.046	<0.001***	1.606	1.466 to 1.757
2006	0.447	0.045	<0.001***	1.563	1.429 to 1.707
2007	0.413	0.045	<0.001***	1.511	1.381 to 1.650
2008	0.392	0.046	<0.001***	1.480	1.351 to 1.618
2009	0.569	0.069	<0.001***	1.766	1.544 to 2.023
2010	0.526	0.076	<0.001***	1.693	1.461 to 1.968
2011	0.596	0.073	<0.001***	1.816	1.575 to 2.099

Continued

**Table 2** Continued

Variables	β	SE	P value	EXP (β)	95% CI
2012	0.688	0.071	<0.001***	1.991	1.735 to 2.289
2013	0.616	0.079	<0.001***	1.851	1.589 to 2.165

P<0.01, *p<0.001.
Exp(B), exponential of coefficients; ICU, intensive care unit; LOS, length of stay; NISS, New Injury Severity Score; NOM, non-OM; OM, operative management.

who sustain major trauma have been shown to experience higher mortality rates and higher economic burdens on families and societies. In our study, age over 65 years had a longer LOS, higher DMC and mortality. Management of splenic injury in the elderly population remains controversial. Tsugawa *et al*²⁵ believed initial operative intervention in the elderly, as signs of shock and severe injuries are not obvious in elderly patients. However, Warnack *et al*²⁶ advocated for which modality of management doctors choose depending on the actual situation of the patient. Considering the high mortality and cost in elderly patients, we believe a multiple disciplinary team is needed to identify and assess the worst-off senile patient's condition.

In this study, drug cost was the main contributor to average splenic injury-related DMC in NOM or OM, followed by hospitalisation costs (figure 2). This phenomenon might be explained from two sides. From the supply side, Chinese doctors can obtain a 15% profit margin from the monetary values of drugs they prescribed according to the drug mark-up policy.²⁷ From 2009 to 2015, this policy was gradually ended in hospitals of all sizes, but overall hospital expenditure is still increasing.²⁵ From the demand side, patients in China are obsessed with medication therapy when they are ill.²⁸ Before 2009, pharmaceuticals accounted for above 40% of public hospitals' revenue in China. After healthcare system reforms in 2009, the rate of revenue began to slowly decline due to mark-up removal but still accounted for about 39% of public hospitals' revenue.²⁹

There are some limitations in our study. First, we cannot tell what type of NOM was adopted in patients due to the lack of related code in CTDB. Second, the categories of DMC cannot be extracted from 2010 to 2013 due to this part of the data was missing at that time in the datasets, we just extracted the total DMC of patients during that period. Third, patients' comorbidities and concomitant injury were not included in CTDB, so we cannot further evaluate the impact of these indicators on DMC. Fourth, because the insurance types were not recorded in this database, we cannot estimate patients-related medical care utilisation or provide a comprehensive cost analysis of patients with splenic injury. Despite these limitations, this study estimates to analyse DMCs of splenic injury and potential factors affecting the costs, as well as to provide evidence to develop specific and cost-effective interventions based on the cost estimations in this study.

CONCLUSIONS

This study is the first, to our knowledge, to describe DMC for splenic injury in China. China's health system always bears amounts of economic burden, coupled with a lack of effective incentives to improve health workers' motivation and laws to protect doctors from violence, which may have a significant influence on the management and cost of patients with splenic injury. This research will be useful for government and health administration services to reform the healthcare policies to contain trauma-related medical costs in the future and provides useful evidence for the management of splenic trauma in China.

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Contributors YC, QZ, and J-HZ conceived and designed the study. YL, YM and YQ participated in data collection and analysis. YC participated in writing. J-HZ, QZ, and YC were responsible for statistical analysis. All authors read and approved the final manuscript. Both J-HZ and YC are responsible for the overall content of the study as guarantors. All the authors read and approved the final version.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Ethics committee of Army Medical Center of PLA approved this study for our ethics approval (2022-63). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. The database used and/or analysed during the study are available from the corresponding author on reasonable request.

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