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Trauma

The adherence of adult trauma centers to American Pediatric Surgical Association guidelines on management of blunt splenic injuries☆

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ABSTRACT

Background: Nonoperative management (NOM) is commonly utilized in hemodynamically stable children with blunt splenic injuries (BSI). Guidelines published by the American Pediatric Surgical Association over the past 15 years support this approach. We sought to determine the rates and outcomes of NOM in pediatric BSI and compare trends between pediatric (PTC), mixed (MTC) and adult trauma centers (ATC).
Methods: This was a retrospective database analysis of the NTDB data from 2011 to 2015 including pediatric patients with BSI, as described by ICD-9-CM Codes *865.00–865.09*. Patients with head injuries with AIS > 2, multiple intraabdominal injuries, and transfers-out were excluded. According to ACS and/or state designation, trauma facilities were defined as PTC (*level I/II pediatric only*), MTC (level I/II adult and pediatric) and ATC (level I/II adult only). OM group was defined as presence of procedure codes reflecting exploratory laparotomy/laparoscopy and/or any splenic procedures. NOM group consisted of patients who were observed, transfused or had transarterial embolization (TAE). Variables analyzed were age, ISS, spleen AIS, amount and type of blood products transfused, and intensive care unit (ICU) and hospital (H) length of stay (LOS).
Results: 5323 children met the inclusion criteria. 11.4% received care at PTC (NOM, 97%), 40.7% at MTC (NOM, 89.9%) and 47.8% at ATC (NOM, 83.8%) ($P < 0.001$). In NOM group, PTC patients had the highest spleen AIS (3.46 ± 0.95, $P < 0.001$). TAE was predominantly used at MTC and ATC ($P = 0.001$). MTC and ATC were more likely to transfuse than PTC ($P = 0.002$). MTC and ATC OM rates were lower in children aged ≤12 than in children aged > 12 ($P < 0.001$). Splenectomy rate was 1.5% at PTC, 8.4% at MTC, and 14.4% at ATC ($P < 0.001$). In OM group, PTC patients had a higher ISS ($P = 0.018$) and spleen AIS ($P = 0.048$) than both MTC and ATC. The proportion of patients treated by NOM at ATC increased during the 5-year period studied ($P = 0.015$). Treatment at MTC or ATC increased the risk for OM by 3.89 and 5.36 times respectively ($P < 0.001$).
Conclusions: PTCs still outperform ATCs in NOM success rates despite higher ISS and splenic injury grades. From 2011 to 2015, ATC OM rates dropped from 17% to 12.4% suggesting increased adoption of the APSA guidelines. Further educational initiatives may help augment this trend.
Level of evidence: II
Type of study: Retrospective.

Evidence emerged almost 70 years ago, demonstrating the association between splenectomy in the pediatric patients and the development of Overwhelming Postsplenectomy Infection (OPSI). The age of the patient at the time of splenectomy appeared to influence the incidence and severity of the condition with the youngest having the highest risk [1]. Subsequent research demonstrated a predisposition to infection with encapsulated germs and showed the incidence and mortality of OPSI were double in pediatric population (6% vs 3%) when compared to adults [2,3]. Incentivized by these findings, pediatric surgeons successfully attempted, developed and standardized nonoperative management (NOM) for pediatric blunt splenic injuries (BSI) as the standard of care since the early 80's [3–6].

In the United States, the disparity in access to specialized pediatric trauma care was reflected in disparities in the management of pediatric BSI. Evidence published during the 90's showed only 16% of the pediatric BSI being cared for by pediatric surgeons and operative rates as low as 20% for pediatric and as high as 52% for adult facilities [7,8]. Acknowledging this disparity, the American Pediatric Surgical Association

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(APSA) published the first set of evidence-based guidelines for the management of pediatric BSI in 2000 [9]. The Eastern Association for The Surgery of Trauma Practice Management Guidelines followed shortly, recognizing NOM for BSI as the standard in children and preferred treatment in adults [10].

For the past 2 decades, closing the gap in terms of rates of NOM and splenectomy for BSI between pediatric and adult trauma centers has been a focused trauma quality improvement process. The recommended operative rate is 3% for isolated splenic injuries and 5%–11% for those with multiple injuries [11]. Polites et al. showed on 2010–2011 NTDB data, an absolute improvement in NOM rates at ATC when compared to mid-90's [12]. The primary goal of this study was to establish whether this increased proportion of patients treated by NOM at ATC was consistent and part of a significant trend over an extended period of time. The secondary goal was to thoroughly compare the characteristics of the patients treated at adult, mixed (MTC) and pediatric trauma centers (PTC).

1. Methods

The study design is a retrospective database analysis which included pediatric patients aged 0–18 from the National Trauma Databank (NTDB) 2011–2015. We included patients with splenic injuries as described by ICD9 D-Codes 865.00, 865.01, 865.02, 865.03, 865.04, and 865.09 who had at least one diagnostic procedure (ultrasound, CT scan or exploratory laparotomy) code to confirm the splenic injury who were admitted to operating room, intensive care unit, step-down unit, surgical floor or observation. The "*transfer*" variable offered by NTDB, marks patients brought from the field as *"0"* and patients who arrive as transfer from other facilities as *"1"*. If both transferring and receiving facilities are reporting data to NTDB, the transferred patient is reported twice (2 different incidence keys): first as a *"0"* by the transferring facility and second time as a *"1"* by the receiving facility. For this reason, all patients who had *"transferred to another facility"* as Emergency Department Disposition were excluded.

In order to accurately identify patients with multiple intraabdominal injuries and/or head injuries with AIS >2, we deconstructed the Injury Severity Score (ISS) offered by NTDB into its 3 severity components. Using the predot portion of the AIS codes associated to postdot severities used in calculating the ISS, we mapped these injuries to the 6 body regions (head/neck, face, thorax, abdomen/pelvic contents/lumbar spine, extremities/pelvic girdle and external). Because ISS calculation includes only the highest AIS score per body region, we used ICD-9 Diagnostic codes to identify and exclude patients with multiple intraabdominal injuries (liver, kidney, stomach, small and large bowel, mesentery). AIS version 98 predot roots 544,210 to 544,228 were used to identify splenic injuries and the corresponding postdot digit was used as Spleen AIS. All patients with a head AIS > 2 were excluded.

Receiving facilities were defined based on the American College of Surgeons (ACS) certification and state designation, as follows: 1) pediatric (PTC—level I/II pediatric only ACS and/or state designation) 2) mixed (MTC—level I/II adult and pediatric ACS and/or state designation) and 3) adult (ATC—level I/II adult only ACS and/or state designation). Facilities with no recorded ACS certification or State designation were excluded.

The presence of procedure codes reflecting splenic procedures was used to define operative management (OM) group. Nonoperative management (NOM) group included patients who were observed (no procedure codes indicative of transfusion of blood products), patients who were transfused, and patients who had transarterial embolization (TAE).

Independent variables included were age, gender, vital signs on presentation, ISS, spleen AIS, amount of blood products transfused (whole blood, packed red blood cells, fresh frozen plasma, coagulation factors) type of receiving facility, length of stay in the intensive care unit (ICU-LOS) and hospital length of stay (H-LOS).

Analysis of variance (ANOVA) with post-hoc analysis chosen based on the homogeneity of variances was used to compare the characteristics of the patients by the type of receiving trauma facility. ISS and spleen AIS were compared as both continuous and ordinal variables (Mann–Whitney nonparametric test). Chi-squared test was used to compare proportions [13,14]. Multivariable analysis (binomial logistic regression) was used to determine the risk factors associated with OM and in establishing trend significance (Cochrane method).

It is currently accepted that puberty starts between ages of 9 and 15 [15]. Age of 12 (midinterval) was chosen as a cutoff for comparing the injury severity and rates of NOM between younger and older children across facilities.

2. Results

A total of 12,992 pediatric patients with BSI were identified. Of these, only 6678 patients had the injury confirmed by a CT scan, ultrasound or procedure code reflecting transfusion, transarterial embolization or splenic operation performed at the NTDB reporting center. After excluding patients who were transferred or had head injuries with AIS > 2, 5323 patients were included in the study. Of these, 11.4% of patients received care at PTC, 40.7% at MTC and 47.8% at ATC ($P < 0.001$). The proportion of pediatric patients with blunt splenic injuries treated at MTC increased from 39.5% in 2011 to 42.5% in 2015 ($P = 0.001$) (Fig. 1).

2.1. Cohort characteristics

Patients treated at MTC (12.62 ± 4.84) were older than those at PTC (9.76 ± 4.75; $P < 0.001$) and younger than those at ATC (14.85 ± 3.87, $P < 0.001$). This difference between the mean age among facilities remained significant within the treatment groups (observed, NOM, OM) at similar levels of significance.

Out of a total of 5323 patients, only 2674 had vital signs (HR, SBP, RR, GCS, SpO2, T, RTS) recorded. Of these, only 11.3% patients ($N = 301$) presented with SBP < 100. 71 patients had OM (23%). There were no significant differences in the distribution of these patients across facilities or in their management.

Patients treated at PTC had the lowest overall mean ISS (17.1 ± 11.56) when compared to MTC (18.85 ± 11.84, $P = 0.001$) and ATC (19.04 ± 11.52, $P < 0.001$) (Table 1). Children aged 12 or younger who were treated at ATC had significantly lower ISS (15.93 ± 10.82 vs 19.74 ± 11.56, $P < 0.001$) and splenic injury grades (2.91 ± 0.92 vs 3.02 ± 0.95, $P = 0.028$) than those older than 12. The ISS of children older than 12 treated at PTC was lower than those treated at MTC and ATC ($P < 0.001$) (Table 2).

2.2. Nonoperative management (NOM) group

The incidence of NOM throughout the 5-year period studied was 87.8%. Of patients managed nonoperatively, 70.8% were observed only, 11.2% were transfused and 5.8% had transarterial embolism (TAE).

The mean age of the patients was significantly different among facilities, with the youngest patients being treated at PTC and the oldest at ATC. The significance was preserved across the NOM (with all its subgroups) and OM groups ($P < 0.001$).

In patients who were observed, the mean *ISS* of patients who were observed at PTC was significantly lower than those observed at MTC ($P = 0.011$). The mean Splenic Injury Grade (AIS) was the highest in patients treated at PTC in both observed (2.93 ± 0.85) and transfused (3.46 ± 0.95) subgroups ($P < 0.001$). Patients treated at MTC also had a higher mean spleen AIS in both observed (2.81 ± 0.83) and transfused (3.15 ± 0.9) subgroups than those treated at ATC ($P < 0.001$). Intensive care unit (ICU-LOS) and hospital length of stay (H-LOS) were not different across facilities among patients who were observed or transfused.

Transarterial embolism (TAE) was employed in 311 (5.8%) patients with 10 at PTC (0.2%), 110 at MTC (2%) and 191 at ATC (3.6%). TAE

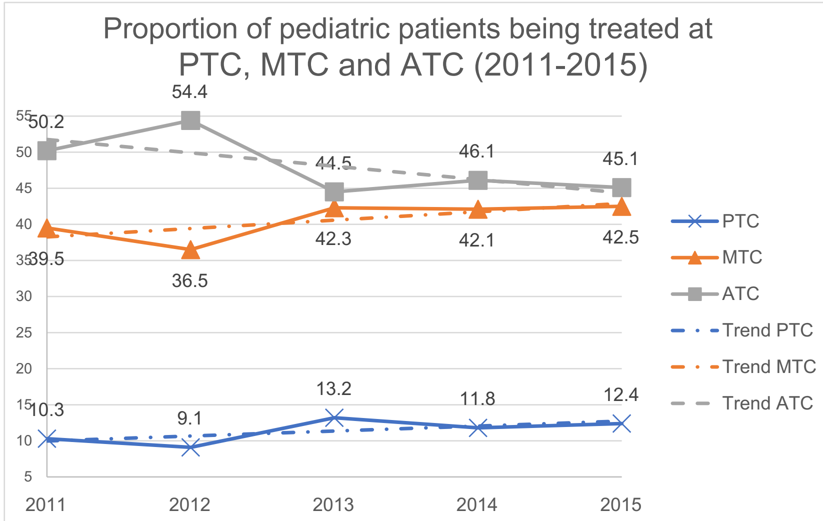

Fig. 1. Increasing proportion of pediatric patients treated at MTC (P=0.013) and PTC (P=0.026); in the same period, the proportion of patients treated at ATC decreased (P<0.001).

failure rates at MTC and ATC were 5.5% and 4.2% respectively (P = 0.6). At PTC, 2 patients out of a total of 10 (20%) required OM in spite of embolization. These patients had ISS of 35 and 50 and Spleen AIS of 5 and 4, respectively. TAE utilization was significantly higher at ATC (7.5%) when compared to MTC (5.1%, P = 0.001) and PTC (1.6%, P < 0.001). The mean ISS and spleen AIS of patients who had TAE at PTC were significantly higher than those at both MTC and ATC (P < 0.026). Patients treated at MTC had longer ICU (P = 0.001) and hospital (P = 0.009) stays when compared to ATC.

In patients treated nonoperatively but who were administered blood products, only 14.7% of patients treated at PTC were transfused, significantly less than at both MTC (18.8%, P = 0.023) and ATC (20.2%, P = 0.002). The proportions of patients who were transfused at MTC and ATC were similar (P = 0.26). In terms of quantity, ATC transfused significantly more packed red blood cells than the other facilities (P = 0.036). The differences in the use of other blood products like fresh frozen plasma (FFP), coagulation factors (CF) and platelets across facilities, were not statistically significant.

2.3. Operative management (OM) group

OM incidence was 3% at PTC, 10.1% at MTC and 16.2% at ATC (P < 0.001) (Table 3). PTC and MTC OM rates for children aged 12 or younger were similar (3.4% vs 5.6%, P = 0.117) and significantly lower than at ATC (9%, P = 0.022). In children older than 12, PTC had the lowest OM rate (2.2%), followed my MTC (13.1%) and ATC (17.9%) (P < 0.001) (Table 4). Children aged 12 or younger who were treated at MTC or ATC had significantly lower OM rates than older children treated at the same facilities (P < 0.001).

Total splenectomy was performed in 86.2% of the patients in the OM group with an overall incidence of 10.5% (1.5% at PTC, 8.4% at MTC, 14.4% at ATC, P < 0.002). Partial splenectomies and splenic repairs made up the

Table 1
Demographics/differences between groups.

Group (%)		Variables	PTC	MTC	ATC	P[a]	P[b]
NOM	**Observed**	**Age**	*9.77 ± 4.61*	*12.30 ± 4.84*	*14.49 ± 4.10*	**<0.001**	
	N = 3772	**ISS**	14.71 ± 9.87	***16.24 ± 10.22***	15.89 ± 9.60	**0.011**	**<0.003**
	(70.8)	**AIS**	***2.93 ± 0.85***	*2.81 ± 0.83*	*2.72 ± 0.84*	**<0.001**	**<0.008**
		ICU-LOS	3.35 ± 3.91	3.95 ± 5.71	3.87 ± 5.23	0.35	
		H-LOS	4.68 ± 4.86	5.34 ± 6.54	5.30 ± 6.09	0.09	
	Transfusion	**Age**	*9.63 ± 5.47*	*12 ± 5.30*	*14.74 ± 4.03*	**<0.001**	
	N = 588	**ISS**	*27.25 ± 11.21*	28.27 ± 12.41	*27.64 ± 10.91*	0.73	**0.014**
	(11.2)	**AIS**	***3.46 ± 0.95***	*3.15 ± 0.90*	*2.95 ± 0.86*	**<0.001**	**<0.049**
		ICU-LOS	7.55 ± 9.99	7.59 ± 7.81	8.57 ± 9.19	0.43	
		H-LOS	16.37 ± 35.67	13.67 ± 11.22	12.4 ± 10.38	0.16	
	TAE	**Age**[a]	*11.7 ± 3.74*	*15.01 ± 3.07*	*15.95 ± 2.24*	**<0.001**	
	N = 311	**N (%)**	10 (0.2)	110 (2)	191 (3.6)	**<0.001**	
	(5.8)	**Failure**	2	6	8	0.086[c]	
		ISS	***26.63 ± 10.91***	20.24 ± 11.55	19.67 ± 9.38	**0.013**	**<0.03**
		AIS	***4.25 ± 1.03***	3.63 ± 0.81	3.61 ± 0.72	**<0.026**	**<0.01**
		ICU-LOS	3.38 ± 1.59	***4.41 ± 4.74***	*2.95 ± 1.92*	**0.001**	
		H-LOS	6.50 ± 3.07	***7.60 ± 8.56***	*5.72 ± 3.62*	**0.009**	
OM		**Age**	*9.11 ± 5.54*	*14.58 ± 4.10*	*15.90 ± 2.71*	**<0.001**	
N = 652		**ISS**	***35.28 ± 15.22***	25.73 ± 13.53	26.56 ± 13.66	**0.018**	**<0.015**
(12.2)		**AIS**	***4.44 ± 0.72***	3.83 ± 0.96	3.88 ± 0.93	**0.048**	**<0.016**
		ICU LOS	6.88 ± 6.43	6.34 ± 7.67	6.67 ± 9.51	0.91	
		H-LOS	12.56 ± 10.06	11.11 ± 11.52	10.71 ± 13.02	0.78	
		TTP	1.33 ± 0.46	1.51 ± 4.18	1.20 ± 0.85	0.34	

Values presented as mean ± standard deviation; italicized group(s) significantly different one from another; percent values presented within parenthesis. ICU-LOS, intensive care length of stay; H-LOS, hospital length of stay; TTP, time to procedure (days); TAE, transarterial embolization.

[a] ANOVA.

[b] Mann–Whitney U Test (nonparametric) shows a higher frequency of high AIS and ISS scores at PTC when compared to MTC and ATC.

[c] Pearson Chi-Square.

Table 2
Differences between children ≤12 and >12 across types of trauma facilities.

	ISS			Spleen AIS		
	≤12	>12	P	≤12	>12	P
PTC	17.51 ± 2.24[b]	16.42 ± 10.29[b]	0.263	3.03 ± 0.92	3.09 ± 0.93	0.435
MTC	18.34 ± 12.11	19.18 ± 11.65	0.107	2.99 ± 0.91	3 ± 0.92	0.968
ATC	15.93 ± 10.82[a]	19.74 ± 11.56	***<0.001***	2.91 ± 0.92	3.02 ± 0.95	***0.028***

[a] ISS at ATC lower than MTC (P = 0.001); ISS ATC vs PTC (P = 0.052).
[b] ISS at PTC lower than both MTC and ATC (P < 0.001).

remainder of 13.8%. There was no difference in the use of spleen preserving procedures between facilities.

The mean ISS of patients treated at PTC (35.28 ± 15.22) was significantly higher (P = 0.018) than both those treated at MTC (25.73 ± 13.53) and ATC (26.56 ± 13.66). The mean spleen AIS of patients treated at PTC (4.44 ± 0.72) was also significantly higher (P = 0.048) when compared to MTC (3.83 ± 0.96) and ATC (3.88 ± 0.93).

There was no difference in the in the mean ICU-LOS and H-LOS or in the use of blood products per type of facility (Table 2).

2.4. Trend analysis

A Cochran–Armitage test of trend was used to determine whether a significant linear trend exists between the incidence of NOM at ATC and the year in the period studied. The years studied were 2011, 2012, 2013, 2014 and 2015, and the proportion of patients in the NOM group was 0.83, 0.81, 0.81, 0.84 and 0.87, respectively. The test showed a statistically significant upward linear trend reflecting an increasing proportion of patients treated by NOM at ATC (87.57% vs 83.03%; P = 0.015) during the 5-year period studied. There was no significant trend noted in patients treated at PTC (P = 0.07) (Fig.2).

2.5. Risk factors for OM

A binomial logistic regression was performed to ascertain the effects of Age, ISS, Spleen AIS and type of facility on the incidence of OM. The logistic regression model was statistically significant ($\chi^2_{(4)} = 891.24$, P < 0.001) explaining 29% (Nagelkerke R^2) of the variance in OM incidence, and correctly classified 87.5% of cases with a sensitivity of 22.7% and specificity of 98%. All four predictor variables were statistically significant (P < 0.001) (Table 5). ISS (AOR-1.03, CI [1.02, 1.04]), every point increase in spleen AIS (AOR-2.45, CI [2.21, 2.73]) and treatment at MTC (AOR-3.89, CI [2.25, 6.71]) or ATC (AOR-5.36, CI [3.11, 9.24]) increased the risk for OM (P < 0.001).

3. Discussion

To our knowledge, this is the first study to date to distinguish between dedicated pediatric, mixed and adult pediatric trauma centers and offer a detailed comparison of patient characteristics, management and outcomes of pediatric blunt splenic injuries between these facilities. This disparity in NOM rates in pediatric BSI has been a staple of trauma quality improvement focus in the past 20 years. As detailed below, our study shows this disparity in management is a consequence of 1) a nationwide gap in access to pediatric trauma specialty care and 2) depending on the type of facility, an overlap between adult and pediatric standard practices, predominantly on adolescents.

This study demonstrated that approximately half of pediatric trauma patients with BSI (51.4%) were cared for at trauma centers with ACS or state pediatric designation. This disparity is confirmed and explained by a United States Government Accountability Office report [16] which found that in the 2011–2015 period, only 57% of pediatric population lived within 30 miles from a high-level pediatric trauma center (level I/II pediatric accreditation). This proportion varied widely among states. In the patient cohort studied, the proportion of pediatric patients with BSI treated at MTC increased from 39.5% in 2011 to 42.5% in 2015 (P = 0.001) (Fig. 2). The post-hoc analysis of the facility dataset offered by NTDB showed a steady yearly increase in the total number of reporting facilities, from 254 facilities in 2011 to 376 in 2015. The number of PTC and MTC reporting also increased. In 2011, there were only 13 dedicated pediatric (PTC) level I or II ACS verified or state designated trauma centers and 71 mixed trauma (level I and/or II adult and pediatric accreditation/designation) centers reporting to NTDB. In 2015, the number of reporting facilities increased to 24 and 107, respectively. The combined number of level I and II PTC and MTC as reflected by the 2015 NTDB dataset appears to be double that reported by ACS in 2009 [17].

There was a significant age difference between the pediatric populations being cared for at PTC, MTC and ATC. The mean ages per type of facility were all significantly different, with the youngest being treated at PTC, the oldest at ATC and MTC right in between. Although this finding in itself is not new, the mean age per type of facility we found, is lower than previously published [19–21]. Overall, as shown in Table 5, younger children treated at ATC tend to have lower ISS than at PTC and MTC. Concurrently, older children treated at PTC tend to be less injured than those treated at MTC and ATC. This appears to explain the lower ATC OM rates in younger children. It is safe to conclude the geographical distribution of these trauma facilities influences the demographics of the populations they treat. The U. S. Government Accountability Office report mentioned above finds highly variable access to pediatric trauma services from <20% in certain Mountain and Midwest states to >75% in the Northeast and Pacific Coast. Where present, PTC and MTC tend to receive younger and more severely injured children than ATC. In this study, overall, 73% of children aged 12 and younger were treated at PTC and MTC, while 57% of children older than 12 were treated at ATC.

These data showed significantly lower OM rates at PTC, especially

Table 3
NOM/OM incidence PTC vs MTC vs ATC.

	Facility type			Total	P
	PTC (%)	MTC (%)	ATC (%)		
NOM	591 (97)	1948 (89.9)	2132 (83.7)	4671 (87.8)	***<0.001***[a]
OM	18 (3)	220 (10.1)	414 (16.3)	652 (13.4)	
Total (facility)	609 (11.4)	2168 (40.7)	2546 (47.8)	5323 (100)	

[a] Pearson Chi-Square.

Table 4
NOM/OM rates in children younger vs older than 12 years of age.

		Facility type			Total	P
		PTC (%)	MTC (%)	ATC (%)		
≤12	**NOM**	369 (96.6)	799 (94.4)	*425 (91)*	1593 (94)	***0.022***[a]
	OM	13 (3.4)	47 (5.6)	*42 (9)*	652 (13.4)	
>12	**NOM**	*222 (97.8)*	*1149 (86.9)*	*1707 (82.1)*	3078 (84.8)	***<0.001***
	OM	*5 (2.2)*	*173 (13.1)*	*372 (17.9)*	550 (15.2)	
Total (Facility)		609 (11.4)	2168 (40.7)	2546 (47.8)	5323 (100)	

[a] Pearson Chi-Square; NOM rate at PTC not significantly different from that at MTC (P = 0.117).

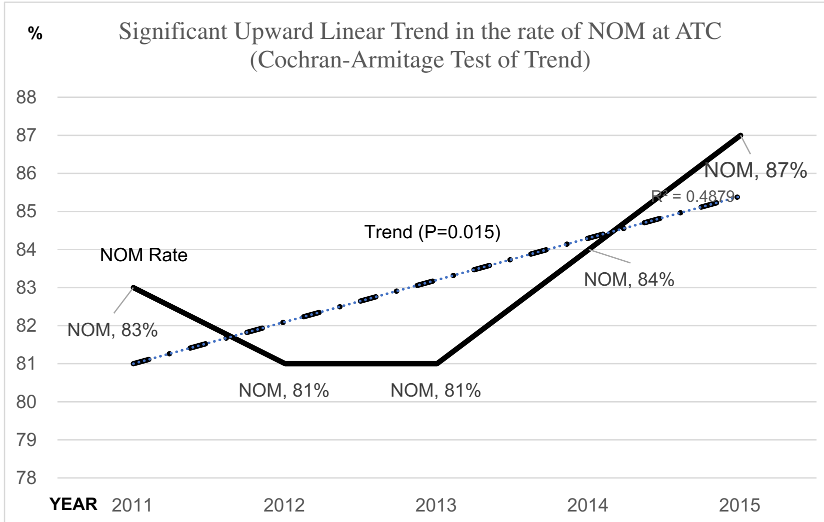

Fig. 2. Cochran–Armitage Test of Trend showing a positive upward trend in the rate of use of NOM at ATC (P = 0.015)

after adjusting for splenic injury grade. MTC performance in terms of OM rates was similar to PTC for children aged 12 and younger. For children older than 12 however, the OM rates at MTC, although significantly lower than ATC, were almost 4 times higher than at PTC. ATC with high pediatric BSI case volume tend to have lower OM rates [22]. More efficient state transfer protocols may have increased ATC pediatric BSI case volume, with recent data showing more than half of pediatric blunt solid organ injuries arriving as transfers from lower level trauma centers [23].

In the past decade TAE has emerged as an important adjunct in the NOM of splenic injuries in adults [24]. Current evidence suggests TAE is just as effective and safe as an alternative to splenectomy in the pediatric population [25]. Our study found TAE almost exclusively used at MTC and ATC. Owing to anatomical particularities of the younger children [5] (elastic ribs, less bulkier splenic parenchyma, thicker splenic capsule and increased number of myoepithelial cells within the spleen), the presence of a contrast blush on abdominal CT scan does not appear to predict failure of NOM [26]. Published evidence is equivocal. A 2010 review found an overall 28% NOM failure rate in children with contrast blush when TAE was not available and a 6.5% failure rate when NOM was supplemented by TAE [27]. A single institution (mixed trauma center) study [28] found no difference in NOM failure rates in spite of higher utilization of TAE by the adult trauma service. In our study, failure rates of 4.2%–5.5% are consistent with previously published literature and remain lower than in the adult population [26,28].

When OM was considered, total splenectomy was employed in 85.4% of the cases with the remainder consisting of splenic salvage procedures (10.1% splenic repairs and 2.1% partial splenectomies). This low rate of successful splenic salvage only reemphasizes the importance of NOM. Trend analysis found a significant upward trend of the in the NOM rates in ATC which suggests increased implementation and compliance with APSA guidelines on management of blunt splenic injuries in children.

Table 5
Risk for OM adjusted for age, ISS, splenic AIS and type of facility.

	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I.	
							Lower	Upper
Age	0.12	0.013	85.95	1	< ***0.001***	1.12	1.1	1.15
ISS	0.03	0.004	86.04	1	< ***0.001***	1.03	1.02	1.04
Spleen AIS	0.9	0.05	272.48	1	< ***0.001***	2.45	2.21	2.73
Trauma facility (MTC)[a]	135	0.278	23.92	1	< ***0.001***	3.89	2.25	6.71
Trauma facility (ATC)[a]	1.5	0.278	36.65	1	< ***0.001***	5.36	3.11	9.24

[a] PTC reference category.

4. Limitations

We used a methodology different from that of previous studies dealing with the matter: 1) trauma facilities were split into 3 categories, with dedicated pediatric trauma centers as a separate category; for this purpose, both ACS verification and state designation were used; 2) in order to minimize the imputation for missing data and errors in reporting, we excluded all patients diagnosed with blunt splenic injuries which did not have a concomitant procedural code of a diagnostic imagistic procedure to confirm the diagnosis was made during that same admission (incident key). Applying this methodology, we excluded 6314 patients who had an ICD-9 Diagnosis Code of BSI, but no imaging or therapeutic procedure code attached to the incident key. These patients may have been transferred already diagnosed and stabilized from different facilities. Since these patients had no logged procedures, it can be inferred they were just observed, or transferred to facilities where they were observed. Running the analysis including the excluded patients revealed NOM/OM rates comparable to what was previously published [12]. Excluding these patients resulted in higher OM and lower NOM rates in all the 3 categories of trauma facilities proportionally, but no change in absolute values of OM rates. While these results do increase the contrast between facilities, they do not represent a fundamentally new finding in terms of the overall incidence of NOM at PTC, MTC and ATC. This methodology removes the unfair advantage of the receiving facilities who benefit from patients diagnosed and deemed stable for transfer.

5. Conclusions

NOM rates of pediatric splenic injury at ATCs are increasing and have approached but not matched those at PTCs. As the access to dedicated PTC is limited nationwide, a viable option to further increase NOM rates would be to promote American Pediatric Surgical Association Guidelines on management of blunt splenic injuries and create policy to encourage more ATCs to apply for ACS and/or state level pediatric accreditation. This would effectively increase the number of MTCs which have shown consistently higher NOM rates than ATCs throughout the studied period.

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