

Original Article

Review of pediatric abdominal trauma: operative and non-operative treatment in combined adult and pediatric trauma center

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Aim: More than 90% of pediatric solid organ abdominal injuries are treated non-operatively. It remains difficult to decide who should graduate to surgical management, more so if adult physicians must make these decisions on pediatric patients. The purpose of this study was to examine outcomes of all pediatric abdominal trauma cases in a single center, focusing on the decision-making algorithm for operative or non-operative treatment by pediatric and adult physicians.

Methods: We undertook a retrospective review of a pediatric trauma database from April 2006 to March 2016. Groups were divided into operative and non-operative, single or multi-organ injury, and adult or pediatric physician. Operative treatments included laparotomy or interventional radiology procedures. Primary outcome was survival within 30 days.

Results: There were 53 abdominal trauma cases; among them, 48 (90.6%) survived and 5 (9.4%) died within 30 days. The probability of survival for mortalities was less than 11%. Forty-two cases were treated non-operatively and 11 operatively. Injury Severity Score was higher in operative group (17 [9, 41]/9 [4, 16.3]). Adult physicians saw 33 patients including seven operative, whereas pediatric physicians saw 20 including four operative cases. There was no statistical difference for the management decision between adult and pediatric physicians.

Conclusion: Our decisions for intervention were within acceptable rates. Adult physicians did not tend to operate more, but there were cases that did not fit the criteria of the algorithm. Further investigation is needed to look at which factors should be focused on to determine whether or not operative treatments are indicated.

Key words: Abdominal trauma, emergency room, non-operative, pediatric, trauma

INTRODUCTION

ROAD INJURY IS one of the leading causes of mortality in children worldwide, including Japan.^{1,2} Although mortality due to traffic incidents has decreased over 30 years in Japan, unintentional injury is still a common cause of death for children. Road traffic incidents are the most common cause of unintentional injury.³

Over the past several decades, the care of abdominal trauma has changed dramatically as non-operative

management has become the standard of care.^{4–8} More than 90% of pediatric solid organ abdominal injuries are treated non-operatively. However, it is certain that some of the patients need operative treatment. Many management algorithms for abdominal injury have been studied in the past. Most of them are based on hemodynamic stability and/or hemoglobin monitoring as a surrogate of ongoing blood loss. However, even though non-operative management tends to work in isolated solid organ injuries, it is still difficult to decide when faced with multiple organ injuries. In addition, there are organs that are difficult to be cured by non-operative management, such as pancreatic ductal injuries, hollow viscus injuries, and penetrating injuries. Furthermore, pediatric trauma cases are not always seen by physicians who are specialized in pediatrics. In our institution as well, both adult and pediatric physicians see pediatric trauma.

In order to further our insights on the influences of surgical decision making, we analyzed all pediatric abdominal trauma cases including cardiopulmonary arrest (CPA; on

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Received 8 Jan, 2019; accepted 19 Mar, 2019; online publication 7 Apr, 2019

Funding Information

No funding information provided.

arrival) cases in our hospital, focusing on how the management plans were made.

METHODS

IN A SINGLE institution, a retrospective review of the pediatric trauma database was carried out to identify all patients younger than 15 years of age admitted to our hospital between April 1, 2006, and March 31, 2016. There are 289 adult critical care medical centers in Japan, and 14 centers are certified as pediatric critical care medical centers. Five hospitals are registered as both adult and pediatric critical care medical centers, and our hospital is one of them. Our hospital is unique in the sense that it has both adult and pediatric wards and is authorized as both an adult and pediatric critical care medical center. In addition, it is known as the only children's hospital in Okinawa prefecture in Japan. Okinawa has many islands around the mainland. The population in Okinawa is 1.43 million in total, including 0.13 million on islands. Most severe pediatric cases from remote islands and the southern part of the mainland are transferred to our hospital by ambulance and helicopter.

Patients with trauma related to abdominal injury were selected for study. Injury was graded using the following trauma scoring systems based on techniques including X-ray, computed tomography (CT), and laboratory data: Injury Severity Score (ISS), Revised Trauma Score (RTS), and the Probability of Survival (Ps), which is predicted by the Trauma and Injury Severity Score.

Non-operative management was compared with operative management. Operative management includes laparotomy as well as transcatheter arterial embolization (TAE) using interventional radiology (IVR) procedures. In our institution, because of the lack of a laparotomy setting at the emergency department, patients who need hemostasis will have IVR procedures instead of laparotomies. In addition, from the view of damage control resuscitation, TAE is one of the ideal ways of controlling hemodynamically unstable patients. Patients who are treated operatively for associated non-abdominal injuries were counted as non-operative management in this study; operative management is focused on abdominal injury.

Outcome was assessed by morbidity or mortality within 30 days from arrival. In each patient we evaluated which organ was injured and what kind of treatments were undertaken.

Furthermore, our cases were analyzed to determine whether it was a single or multiple organ injury, and seen by an adult or pediatric physician.

RESULTS

OVER THE 10-YEAR period, within 800 trauma patients, 747 were excluded and a total of 53 patients with abdominal trauma met inclusion criteria for our study (Fig. 1). The most common mechanism of injury was motor vehicle incident (47.2%), followed by fall (20.8%), bicycle incident (5.7%), sports related (5.7%), stab wound (1.9%), and other blunt injuries (18.9%). Forty-eight patients (90.6%) survived and five patients (9.4%) died within 30 days of arrival. Non-operative management was used in 42 patients. Eleven patients underwent operative therapy, which included seven patients (63.6%) who survived and 4 (36.4%) who died. All of the 42 non-operative patients survived except for one who was involved in a severe traffic incident and died despite of cardiopulmonary resuscitation before any operative procedures could be carried out. Comparative trauma scores in the survival and death groups (median [25, 75%]) were: ISS 9 (4.3, 16)/41 (34.5, 52.5), RTS 7.8 (7.6, 7.8)/1.3 (1.2, 1.6), and Ps (%) 100 (99, 100)/4 (0.5, 8), respectively.

Patient characteristics are shown in Table 1. Twenty of 26 liver injuries, 13 of 14 splenic injuries, and two of five intestinal injuries were treated non-operatively. One grade IV pancreatic injury was treated operatively, whereas another grade II pancreatic injury was treated non-operatively. Comparing operative and non-operative groups, the operative group had more associated injuries (54.5%/26.2%) and higher ISS score (17 [9, 41]/9 [4, 16.3]). In terms of ISS score, the injury is considered as severe when ISS is more than 15. Most patients in the operative group had an ISS greater than 15, but not all high ISS score patients received operative management (Fig. 2). The comparative trauma scores in the operative and non-operative groups were: ISS 17 (9, 41)/9 (4, 16.3), RTS 7.8 (1.3, 7.8)/7.8 (1.3, 7.8), and Ps (%) 99 (4, 100)/100 (99, 100), respectively.

The details of 11 operative patients are shown in Table 2. Multiple organ injuries were found in five out of 11 cases. Indication of operative management was unstable vital signs, free air, and extravasation in image studies, and exacerbation of symptoms. In six of 11 operative cases, emergency room (ER) doctors or adult general surgeons made decision of intervention. Operative treatments included intra-abdominal gauze packing in four cases, five TAE by IVR procedures, intestinal resection in three cases, one diagnostic laparotomy case, and three resuscitative thoracotomies. Four out of five mortality cases were in the operative group. All four patients arrived at our hospital in CPA or shock with very low Ps. Within 53 cases, all five mortality cases were multiple organ injuries.

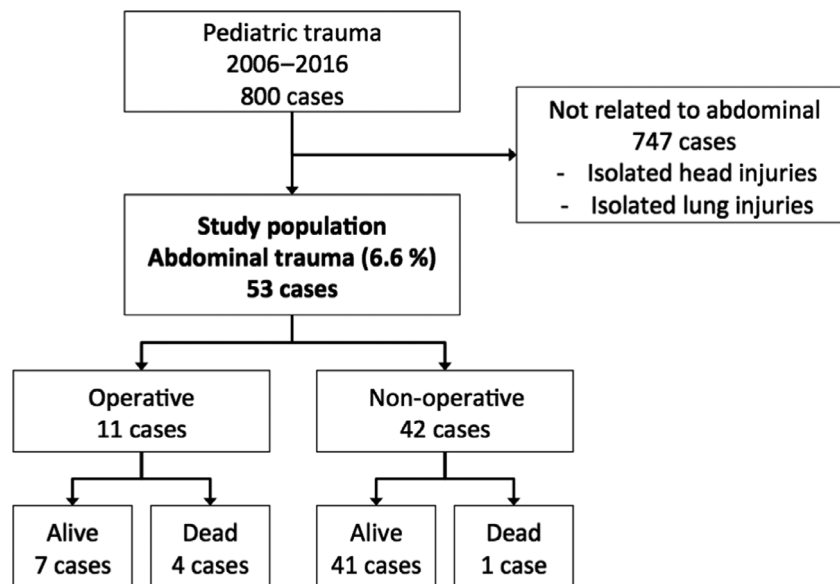


Fig. 1. Final study population of pediatric patients with solid organ abdominal injuries. Percentages represent percent of total pediatric trauma.

In 42 non-operative patients, 31 (73.8%) had single organ injuries (Table 1). There were 13 of 42 cases whose ISS was more than 15 in non-operative group. The requirements for being treated non-operatively are seen in Table 3. Patients had to be stable in vital signs, no exacerbation of symptoms, clinically stable, and be able to be seen at the intensive care unit setting.

Adult physicians saw 33 patients, including seven operative cases; pediatric physicians saw 20 patients, including four operative cases. There was no statistical difference in the management decisions between adult and pediatric physicians.

DISCUSSION

IT TENDS TO be demanding to make decisions whether to operate or not in each case, especially in cases of multiple trauma. However, according to the result of our study, our decisions of intervention were acceptable, because most of the non-operative group survived and the Ps of mortality cases was so low in the first place.

In order to evaluate the decision process of operative or non-operative management, the algorithm of The Arizona-Texas-Oklahoma-Memphis-Arkansas Consortium (ATOMAC) guideline, the guideline published by the American Pediatric Surgery Association, was used. Two cases were treated operatively but should have been treated non-operatively according to the ATOMAC guideline. Adult physicians saw these two cases. These decisions were against the

concept of the ATOMAC guideline. The first case was a 14-year-old girl who had blunt grade IIIa splenic injury. Contrast CT showed fluid collection at pelvis, but there was no evidence of active bleeding, and her vital signs were stable. However, the adult ER doctor decided to proceed to TAE. The second case was a 6-year-old boy who was involved in a motor vehicle incident and had grade IIIb liver injury. Even though vital signs were stable, contrast CT showed extravasation, and the ER doctor and adult surgeon decided to undertake TAE. Both cases were treated as they would if they were adult cases.

Several studies have shown that most liver and spleen injuries are manageable non-operatively,^{4–8} whereas pancreas and intestinal injuries occasionally need operative management.^{9–16} According to our results, six of 26 liver injuries (23.1%) underwent operative management. Within these six operative cases, three arrived in shock or CPA with multiple injuries. The other three cases had extravasation in CT and underwent TAE, although one of them did not have unstable vital signs. This stable TAE case was decided to have embolization by an adult doctor as mentioned. Twenty non-operative liver injury cases were all hemodynamically stable. The only operatively managed splenic injury case had grade IV injury and underwent TAE; the decision for intervention was made by an adult doctor as described previously. Except for the high operative rate for liver injuries, most of our strategy was within the standard non-operative care of pediatric trauma, according to the ATOMAC guideline.

Table 1. Characteristics of 53 pediatric patients with solid organ abdominal injuries

Characteristic	Total (n = 53)	Operative (n = 11)	Non-operative (n = 42)
Age, years; mean (SD)	7.9 (3.7)	9.0 (4.6)	7.6 (3.4)
Male, n (%)	31 (58.5)	5 (45.5)	26 (61.9)
Fatalities, n (%)	5 (9.4)	4 (36.4)	1 (2.4)
Injured organ, n (%)			
Liver	26 (49.1)	6 (54.5)	20 (47.6)
Spleen	14 (26.4)	1 (9.1)	13 (31.0)
Pancreas	2 (3.8)	1 (9.1)	1 (2.4)
Intestine	5 (9.4)	3 (27.3)	2 (4.8)
Abdominal wall	1 (1.9)	0 (0.0)	1 (2.4)
Kidney	2 (3.8)	0 (0.0)	2 (4.8)
Ureter	1 (1.9)	0 (0.0)	1 (2.4)
Pelvis	2 (3.8)	0 (0.0)	2 (4.8)
Associated injuries† (%)			
Any	22 (41.5)	6 (54.5)	11 (26.2)
Thoracic	16 (30.2)	5 (45.5)	11 (26.2)
Cranial	5 (9.4)	4 (36.4)	1 (2.4)
Musculoskeletal	3 (5.7)	2 (18.2)	1 (2.4)
Injury Severity Score, median (25, 75%)	10 (5, 18.5)	17 (9, 41)	9 (4, 16.3)
Revised Trauma Score, median (25, 75%)	7.8 (7.6, 7.8)	7.8 (1.3, 7.8)	7.8 (1.3, 7.8)
Probability of survival, median (%) (25, 75%)	99 (99, 100)	99 (4, 100)	100 (99, 100)

†Excluding laceration and bruising.
SD, standard deviation.

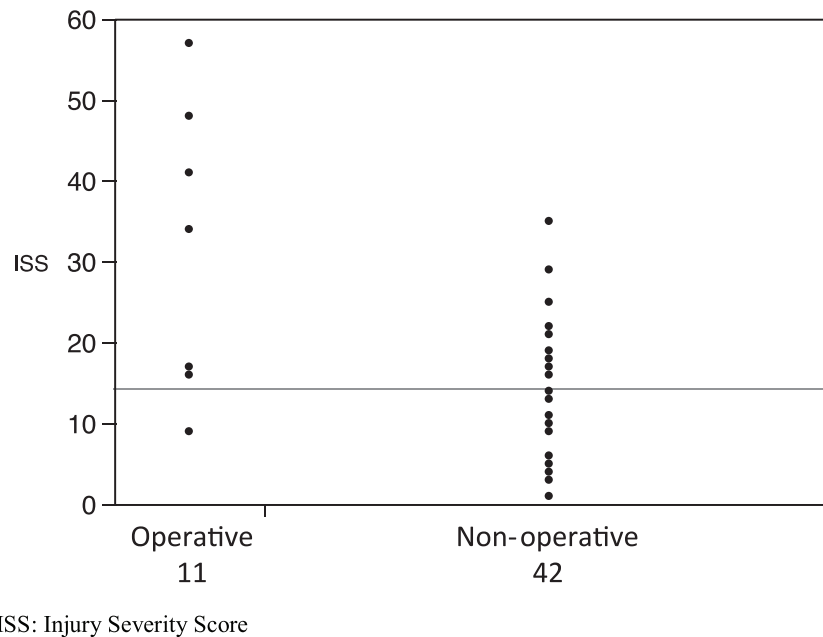


Fig. 2. Distribution of Injury Severity Score scores in operative and non-operative groups of pediatric patients with solid organ abdominal injuries.

Table 2. Eleven cases of operative management of pediatric patients with solid organ abdominal injuries

Mechanism	Organ	ISS	RTS	Ps (%)	Reason for intervention	Decision maker	Method	ATOMAC guideline	Outcome
1 Ascites from spleen rupture	Spleen	16	7.8	99.3	Ascites in CT	ER doctor	TAE	Unmatched	Alive
2 Intestinal perforation	Intestine	9	7.8	99.6	Free air in CT	Pediatric surgeon	Laparotomy	Matched	Alive
3 Multiple trauma	Multiple	34	7.8	97.4	Unstable vital signs	Pediatric surgeon	TAE	Matched	Alive
4 Intestinal perforation	Intestine	9	7.8	99.6	Free air in CT	Pediatric surgeon	Laparotomy	Matched	Alive
5 Liver rupture	Liver	16	7.8	99.3	Extravasation in CT	ER doctor	TAE	Matched	Alive
6 Liver rupture	Liver	17	7.6	99.0	Extravasation in CT	ER/Adult surgeon	TAE	Unmatched	Alive
7 CPA, ascites	Multiple	34	1.9	11.4	PEA, abdominal distention	ER/Adult surgeon	Resuscitative thoracotomy, laparotomy	Matched	Dead
8 Shock, lung rupture, cardiac rupture	Multiple	48	1.3	0.2	Shock, air leak in lung, pericardial effusion	Pediatric surgeon	Resuscitative thoracotomy, laparotomy	Matched	Dead
9 Duodenal rupture	Duodenum	9	7.8	99.6	Free air, abdominal pain exacerbation	Pediatric surgeon	Laparotomy	Matched	Alive
10 CPA, abdominal organ rupture	Multiple	41	1.3	4.1	Shock, abdominal distention	ER doctor	Resuscitative thoracotomy, laparotomy	Matched	Dead
11 CPA, abdominal organ rupture	Multiple	57	1.3	1.2	Shock, abdominal distention	ER doctor	Laparotomy, TAE	Matched	Dead

ATOMAC, Arizona-Texas-Oklahoma-Memphis-Arkansas Consortium; CPA, cardiopulmonary arrest; CT, computed tomography; ER, emergency room; ISS, injury Severity Score; PEA, pulseless electrical arrest; Ps, probability of survival; RTS, Revised Trauma Score; TAE, transarterial embolization.

Table 3. Criteria for non-operative management of pediatric patients with high Injury Severity Score (>15)

Stable vital signs
No exacerbation of symptoms
No increase in ascites
No accumulation of free air in second CT
No significant decrease of hemoglobin in second laboratory test
Close observation in pediatric intensive care unit setting

CT, computed tomography.

Because our institution has both adult and pediatric wards, pediatric trauma cases are not always seen by doctors specialized in children. It is already known that the rate of non-operative management in pediatric trauma centers is higher compared to adult trauma centers, and the prognosis for non-operative treatment is superior to that of operative treatment.^{17–19} At this point, we need to admit that some cases could have been managed non-operatively if patients were seen by pediatric surgeons instead of ER doctors or adult general surgeons. However, the decision to operate when necessary cannot be delayed, even though most pediatric trauma cases were well treated non-operatively. We experienced a case that required urgent intervention, and ER doctors decided to undertake laparotomy without waiting for pediatric surgeons' discussion.

Pediatric trauma management guidelines have been developed in many institutions.^{4,5,20} These guidelines use hemodynamic status as the primary factor in decision-making, as well as the amount of blood loss. Although useful, we sometimes face cases too complicated for these guidelines. Because trauma cases, especially multiple trauma, are not similar to each other, we tend to encounter challenges in deciding what to do next. The order of procedures could be critical to save a patient, not as simple as just deciding whether or not to treat operatively or non-operatively. We had 15 multiple trauma cases out of 53, and five cases (33.3%) received operative treatment. Of the remaining 38 single trauma cases, 6 (15.8%) were managed operatively.

There are limitations in our study. Because our hospital has adult and pediatric doctors, patients were seen with different management strategies. Selection and interventional biases are all factors that could impact the outcome of this study. The guidelines could work well in order to fix the management theory among doctors with different backgrounds, but there are still some complicated cases to contend with.

Another limitation is that we included CPA cases. These cases deviate trauma scores and mortalities. That is the reason why most of the previous studies exclude these CPA cases. However, we thought it would be impossible to study trauma cases without including CPA cases; these cases could be challenging to decide our management, although the prognosis is very poor.

CONCLUSION

IT IS ALWAYS difficult to undertake operative management in a suitable timeframe and with appropriate methods when facing cases that are not treated non-operatively. However, according to the results of our study, our decisions for intervention were acceptable, because most of the non-intervention group survived and the Ps of death cases were very low in the first place. Although ISS is high, patients could be cured non-operatively under certain conditions. Adult physicians did not tend to operate more, but there were cases that did not fit the criteria of the algorithm.

Further investigation is needed to look at which factors should be focused on to determine whether or not operative treatments are indicated.

DISCLOSURE

Approval of the research protocol: This research was approved by the ethical committee at Okinawa Prefectural Nanbu Medical Center and Children's Medical Center on 14 August, 2017.

Informed consent: Consent for collecting the data was obtained from the ethical committee at Okinawa Prefectural Nanbu Medical Center and Children's Medical Center.

Informed consent: As this is routinely collected data needed for patient management, no parent/patient interaction is necessary for data collection. All information extracted is stored in a private electronic database, and are password protected. Once relevant data has been extracted it is anonymized for analysis. Because of the routine nature of the data under investigation, and anonymous handling of extracted data, informed consent is thus not considered necessary for this retrospective review.

Registry and registration no. of the study/trial: N/A.

Animal studies: N/A.

Conflict of interest: None declared.

ACKNOWLEDGMENTS

THE AUTHORS WISH to acknowledge the assistance of Dr. Thomas Hurt and Dr. Ncedile Mankahla in

preparing the English manuscript, Ms. Sakura Ooshiro in collecting data for this research project.

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