World J Surg
DOI 10.1007/s00268-015-2953-4

World Journal of Surgery

ORIGINAL SCIENTIFIC REPORT

Adrenal Gland Trauma: Is Extravasation an Absolute Indication for Intervention?

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Abstract

Background Adrenal gland trauma (AGT) is potentially devastating if unrecognized during the treatment of trauma patients. Because of the adrenal glands' rich vascularity, they often hemorrhage upon traumatic impact. However, there has been no conclusion about the indications for intervention in cases of hemorrhage after AGT.

Methods We conducted a prospective collection with a retrospective review in a Level I trauma center in Taiwan. This study enrolled all of the patients who suffered from AGT from May 2008 to May 2013. We retrieved and analyzed the patient demographic data, clinical presentation, AGT grade, injury severity score, management, hospital stay, and mortality.

Results The cohort consisted of 60 patients. The mean age was 31.0 ± 15.9 years. There were 32 patients (53.3 %) with extravasated AGT, which was associated with a high injury severity score, a high possibility of associated lung injury, and more than one accompanying trauma. Most of the patients could be treated conservatively. Five of these patients needed surgical hemostasis, and four of them needed angiographic embolization. Extravasation combined with a mean arterial pressure <70 mmHg was a predictor of the need for intervention (relative risk: 9.52, 95 % CI 1.64–55.56, $p = 0.011$).

Conclusion In conclusion, AGT is a rare injury with a good prognosis. Most AGT patients can be treated conservatively. Extravasation in AGT is not only a sign of hemorrhage, but also an indicator of severe associated injuries. However, extravasation in AGT does not always require further treatment. When intractable hypotension simultaneously occurs, further treatment should be considered.

Chien-Hung Liao and Kuo-Jen Lin have contributed equally.

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Introduction

Adrenal gland trauma (AGT) is a rare injury because of the location of the adrenal glands, which are located deep in the retroperitoneal cavity and protected by multiple organs [1]. With the prevalent use of abdominal computerized tomography (CT) in trauma patients, an increasing number of AGT cases are being diagnosed in the modern medical environment [2, 3].

Because of their anatomic distribution, the adrenal glands are extremely vascular and hemorrhage easily following trauma. Because of the richness of the vascularity, acute hemorrhage from an adrenal trauma may cause

Published online: 23 January 2015

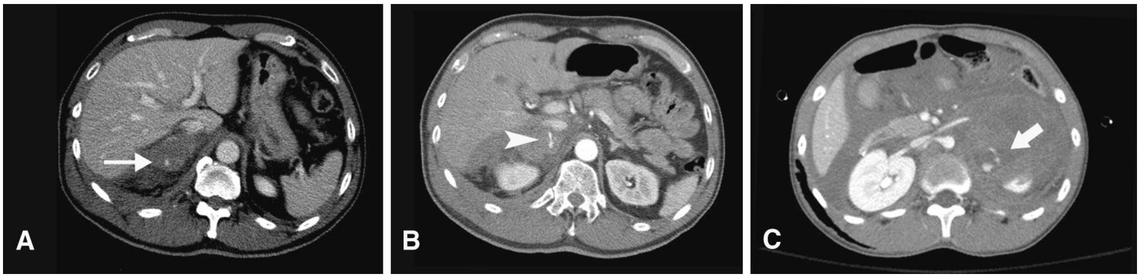

Fig. 1 Characteristics of extravasation in adrenal gland trauma on abdominal computed tomography. **a** An oval low-attenuation hematoma of the right adrenal gland with contrast blushing. **b** A contrast extravasation with periadrenal stranding of the right adrenal gland. **c** Destruction of the left adrenal gland with contrast extravasation. *Arrow* contrast extravasation

unexpected blood loss, resulting in shock and even mortality [4]. Expectant or conservative management is feasible for many visceral traumas. Because of the rarity and diversity of the clinical presentation and prognosis of AGT, no consensus has been reached on how to manage hemorrhage in AGT. Several authors have advised aggressive management and early intervention because of possible life-threatening events, including possible delayed adrenal insufficiency [5, 6]. In contrast, an increasing number of studies have reported that conservative management can be used for patients with AGT [3, 4].

Because of the limited number of AGT cases, it has been difficult to conduct a large study on the significance of this injury. In the present study, we review the details on the incidence, management, and outcome of AGT in a single trauma center and try to identify the factors that necessitate intervention in this trauma.

Methods

Data collection

We conducted a prospective data collection trauma registry in Chang Gung Memorial Hospital (CGMH), Linkou, which is a Level I trauma center in Taiwan. We prospectively recorded the demographic data; trauma mechanism; prehospital, medical, perioperative, and hospital course; follow-up; and information regarding complications in a computerized Trauma Registration System database. We performed a retrospective review of all patients who suffered from AGT from May 2008 to May 2013 in Chang Gung Memorial Hospital, Linkou. The cases were retrieved, including blunt adrenal trauma diagnoses, by filtering the cases according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes (868.01 and 868.11). The dataset was further limited to patients aged greater than 16 years. The study was approved by the Internal Review Board of CGMH.

Study population

All patients with AGT were managed by the trauma team from the time of emergency department arrival to discharge. Patients with thoracoabdominal trauma were managed under the same protocol based on the long-standing principles of advanced trauma life support. The diagnosis of AGT was established by CT. The diagnostic criteria were based on the published characteristics of adrenal hematoma—specifically, a round or oval high-attenuation mass either occupying the adrenal gland region or obscuring the normal adrenal gland, with or without periadrenal stranding (Fig. 1) [7–9]. Cases were excluded if there was a normal adrenal gland but a hematoma in the adrenal gland region that could be explained by hepatic or renal injury. Cases in which the initial CT report described the adrenal glands as normal were also excluded. If pooling was noted around or in the hematoma during contrast imaging, extravasation was considered. The length of the AGT hematoma was calculated as the sum of the longest lengths on two different axes. The AGT grade was determined according to organ injury scaling [10]: Grade I represented only a contusion; Grade II represented an injury that only involved the cortex or was <2 cm in depth; Grade III represented a laceration extending into the medulla; Grade IV represented a >50 % parenchymal disruption; and Grade V represented total parenchymal destruction. Multiple injuries could advance the grade by one, up to Grade V. The image and grading were reviewed by two experienced physicians with expertise in AGT.

Because of the lack of consensus regarding AGT management, we managed these injuries according to the principle of managing other solid organ injuries. For patients with extravasated AGT who had an unstable hemodynamic status and did not respond to initial resuscitation, we performed laparotomy. For patients with extravasated AGT who had unstable hemodynamic status and a transient response after resuscitation, we performed angiography (Fig. 2). For patients with extravasated AGT and a stable hemodynamic status, we continued

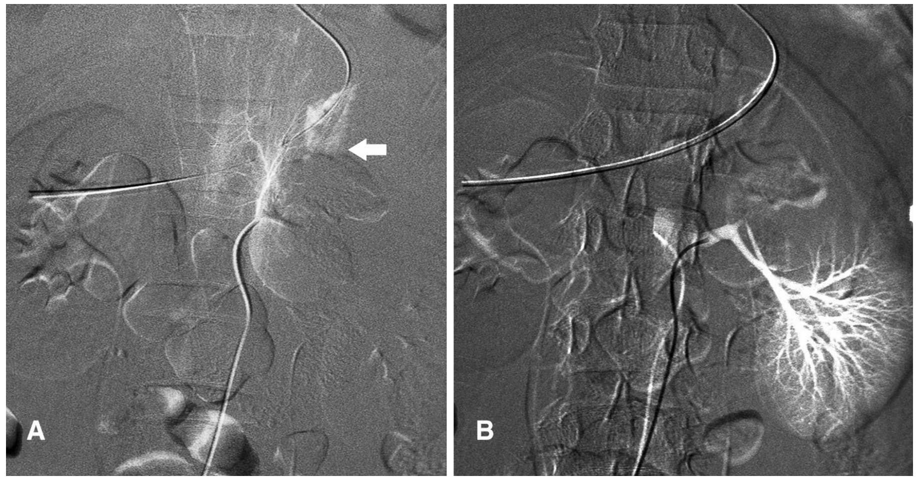

Fig. 2 Angiography in adrenal gland trauma. **a** The left inferior adrenal artery revealed extravasation and torsion of the vascular territory (*arrow*). **b** Post-embolization with gelfoam; no further extravasation was noted

observation and resuscitation. Based on the interventions needed, we divided the extravasated AGT patients into a therapeutic intervention group, which received laparotomy or embolization; a non-therapeutic intervention group, which received diagnostic angiography; and an observation group. We retrieved the demographic data, clinical symptoms and physical findings, associated injuries, AGT grade, Revised Trauma Score (RTS), CT findings and length of AGT hematoma, injury severity score (ISS), and new injury severity score (NISS). The necessity of and the findings from operation and angiography were recorded. The intensive care unit length of stay (ICU LOS), hospital length of stay (HLOS), and mortality were collected. According to the necessity of a definite hemostatic procedure (surgery or embolization), we divided the extravasated AGT patients into the intervention and conservative groups. We excluded patients who had undergone a past adrenal surgery or had a history of adrenal mass as well as those who were lost to follow-up.

Statistical analysis

Pearson's χ^2 test and Fisher's exact test were used to compare categorical variables. Quantitative variables were compared with Student's t test, the Mann–Whitney U test, and analysis of variance (ANOVA). Levene's test was used to correct for intergroup variations before the application of Student's t test. The univariate and multivariate analyses were calculated using logistic regression for binary variables and linear regression for continuous variables. The optimal cutoff values for the continuous variables were identified using receiver operating characteristics (ROC) curves and the Youden index. Statistical analysis was performed with SPSS v 20.0 for Macintosh (SPSS Inc., Chicago, IL, USA). A value of $p < 0.05$ was considered statistically significant.

Results

A total of 148,765 patients were admitted to the trauma bay of Chang Gung Memorial Hospital, Linkou, Taiwan, during the study period. An additional 24,677 patients required further admission. A total of 3,486 patients had blunt thoracoabdominal trauma. The final cohort consisted of 60 patients: 46 males (76.7 %) and 14 females (23.3 %). The incidence of AGT was 1.7 % in all thoracoabdominal trauma patients. The mean age was 31.0 ± 15.9 years. The most common mechanism was related to motor vehicle collision, followed by falling. The adrenal gland injuries were predominantly on the right side ($n = 46$, 76.7 %; left side: $n = 12$, 20.0 %; bilateral: $n = 2$, 3.3 %). Because of the anatomic location of the adrenal glands, 57 patients with AGT (95.5 %) had associated injuries; only 4.5 % of the patients had isolated AGT. The most common associated injuries were liver laceration, followed by rib fracture and pneumohemothorax. The mean ISS was 26.1 ± 13.7; the mean NISS was 28.3 ± 13.3; and the mean RTS was 6.88 ± 1.50. The ICU LOS was 4.7 ± 4.2 days, and the HLOS was 15.0 ± 10.1 days. According to the CT presentation, 28, 7, 4, and 21 patients had an adrenal injury presenting as oval, round, diffuse swelling, and irregularly shaped, respectively. Thirty-two patients had contrast extravasation in CT. There were 12, 29, 17, and 2 patients with AGT grades II, III, IV, and V, respectively (as Table 1).

Dividing the cases by the presence of extravasation in abdominal CT, the demographic data and prognosis of the extravasated and non-extravasated groups are summarized in Table 2. In the extravasated group, there was a higher ISS (31.3 ± 13.7 vs. 20.3 ± 11.4, $p = 0.001$), higher NISS (33.6 ± 12.3 vs. 22.2 ± 12.0, $p = 0.002$), and higher rate of high-grade AGT (46.9 vs. 10.7 %, $p = 0.004$) than in the non-extravasated group. Moreover,

Table 1 The characteristics of patients with blunt adrenal trauma

Characteristics	
Patients (No.)	60
Age (years, mean ± SD)	31.5 ± 14.3
Gender (*n*, %)	
Male	46, 76.7
Mechanism (*n*, %)	
Motor vehicle crash	46, 76.7
Fall	12, 20.0
Crash	2, 3.3
Injury site	
Right	46, 76.7 %
Left	12, 20.0 %
Bilateral	2, 3.3 %
GCS (mean ± SD)	12.2 ± 4.2
SBP (mean ± SD)	110.0 ± 33.5
MAP (mean ± SD)	80.1 ± 26.8
ISS (mean ± SD)	26.1 ± 13.7
NISS (mean ± SD)	28.3 ± 13.3
RTS (mean ± SD)	6.88 ± 1.50
Adrenal trauma grade	
II	13, 21.7 %
III	29, 48.3 %
IV	16, 26.7 %
V	2, 3.3 %
Associated injury (*n*, %)	57, 95.5
Liver	41, 68.3
Rib fracture	28, 46.7
Pneumohemothorax	27, 45.0
Kidney	26, 43.3
Extravasation (*n*, %)	32, 53.3
Emergency angiography (*n*, %)	17, 28.3
Angiographic embolization (*n*, %)	4, 6.7
Operation (*n*, %)	5, 8.3
ICU LOS (days, mean ± SD)	4.7 ± 4.2
HLOS (days, mean ± SD)	15.0 ± 10.1
Mortality (*n*, %)	5, 8.3

GCS Glasgow Coma Scale, *SBP* systolic blood pressure, *MAP* mean arterial pressure, *ISS* Injury Severity Score, *NISS* New Injury Severity Score, *RTS* Revised Trauma Score, *ICULOS* intensive care unit length of stay, *HLOS* hospital length of stay

Table 2 Comparison of the groups with and without extravasation on abdominal computed tomography

	Extravasated group ($n = 32$)	Non-extravasated group ($n = 28$)	*p* value
Age	26.3 ± 15.0	36.5 ± 15.3	0.320
Gender (male, %)	26, 81.2	20, 71.4	0.359
SBP (mean ± SD)	108.5 ± 34.1	116.9 ± 36.4	0.357
MAP (mean ± SD)	79.6 ± 27.0	84.1 ± 29.1	0.537
RTS (mean ± SD)	6.82 ± 1.24	6.95 ± 1.78	0.730
ISS (mean ± SD)	31.3 ± 13.7	20.3 ± 11.4	**0.001**
NISS (mean ± SD)	33.6 ± 12.3	22.2 ± 12.0	**0.002**
Hematoma size (cm, mean ± SD)	7.8 ± 3.3	5.6 ± 1.5	**0.002**
Adrenal trauma grade			
≤III (*n*, %)	17, 53.1	25, 89.3	**0.004**
>III (*n*, %)	15, 46.9	3, 10.7	
Associated injuries			
Liver (*n*, %)	24, 75.0	17, 60.7	0.235
Spleen (*n*, %)	5, 15.6	5, 17.9	1.000
Kidney (*n*, %)	16, 50.0	10, 35.7	0.265
Lung (*n*, %)	18, 56.2	1, 3.6	**<0.001**
Pneumothorax (*n*, %)	17, 53.1	10, 35.7	0.176
>One injury (*n*, %)	32, 100	23, 82.1	**0.018**
ICU LOS (days, mean ± SD)	6.1 ± 4.5	3.2 ± 3.4	**0.008**
HLOS (days, mean ± SD)	16.8 ± 11.7	12.9 ± 7.6	0.145
Mortality (*n*, %)	4, 12.5	1, 3.6	0.359

Bold values are statistically significant ($p < 0.05$)

SBP systolic blood pressure, *MAP* mean arterial pressure, *RTS* Revised Trauma Score, *ISS* Injury Severity Score, *NISS* New Injury Severity Score, *ICU LOS* intensive care unit length of stay, *HLOS* hospital length of stay

higher rates of lung injury (56.2 vs. 3.6 %; $p < 0.001$) and more than one associated injury (100 vs. 82.1 %; $p = 0.018$) were identified in the extravasated group. The extravasated group had a longer ICU LOS than in the non-extravasated group (6.1 ± 4.5 vs. 3.2 ± 3.4; $p = 0.008$). However, the two groups had similar HLOS (16.8 ± 11.7 vs. 12.9 ± 7.6; $p = 0.145$). The mortality rate was 8.3 % in this series. A high probability of mortality was found in the extravasated group (12.5 vs. 3.6 %), but the difference was not statistically significant ($p = 0.359$).

Five of our patients underwent laparotomy. All of these patients had associated organ trauma, including 3 liver lacerations, 2 spleen lacerations and one kidney laceration. In these five patients, we performed one adrenalectomy (combined with splenectomy), two suture ligations, and two retroperitoneal packings. Seventeen patients had angiography, including four embolizations.

We divided the patients into observation, non-therapeutic intervention, and therapeutic intervention groups according to their treatment (Fig. 3). Nine patients were included in the therapeutic intervention group (5 laparotomy patients and 4 embolization patients); 13 patients were

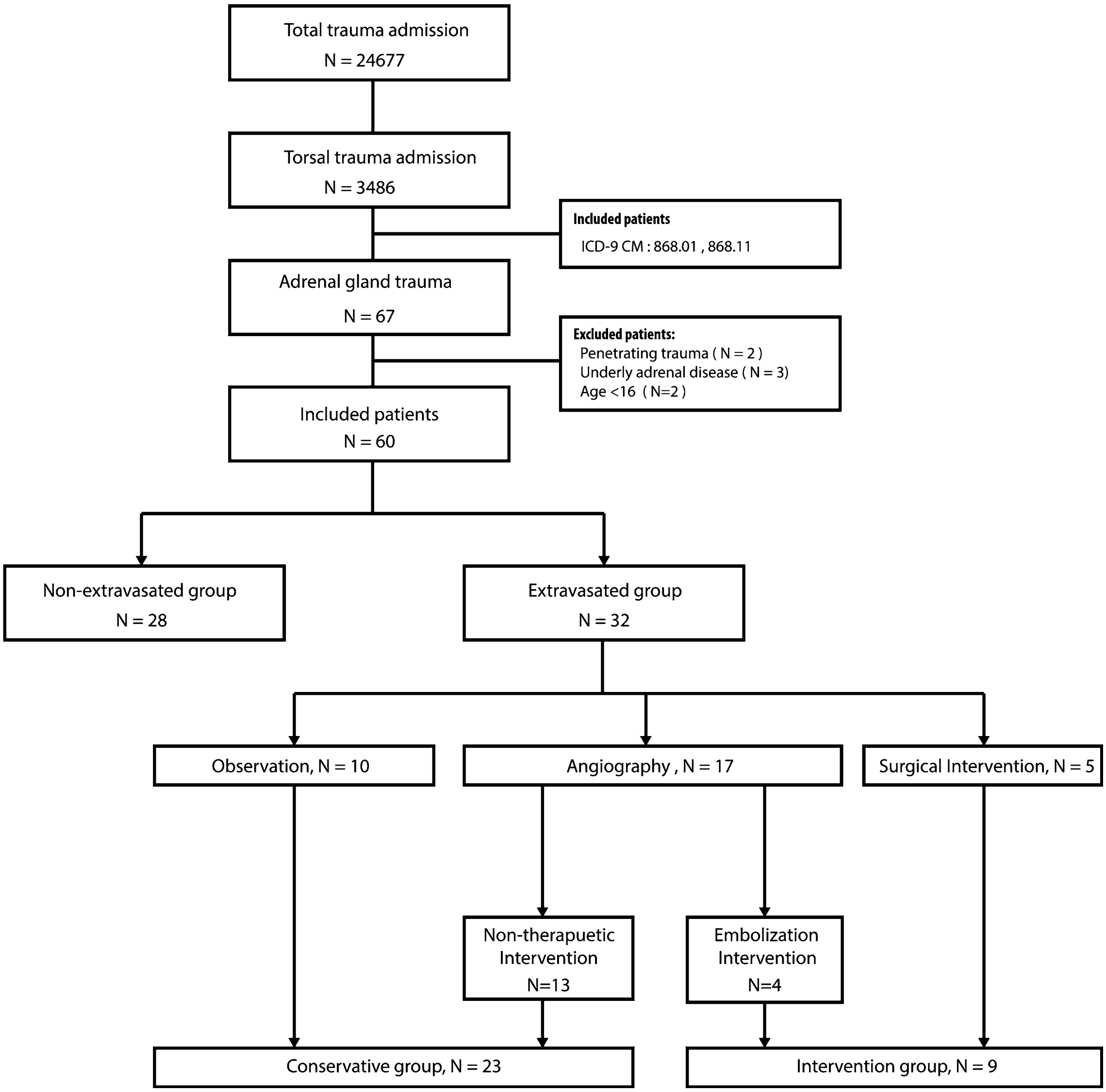

Fig. 3 Consort diagram describing cohort identification. ICD-9-CM: International Classification of Diseases, Ninth Revision, Clinical Modification

included in the non-therapeutic intervention group (diagnostic angiography only), and the remaining 10 patients were included in the observation group. Table 3 shows the data for the detailed comparison of the three groups. The therapeutic intervention group had a lower systolic blood pressure (SBP) and mean arterial pressure (MAP) and a higher AGT grade compared with the other two groups.

In searching for a predictor of the need for intervention in AGT, we further divided the patients into intervention or conservative treatment (including non-therapeutic and observation) groups depending on their need for a definite procedure to achieve hemostasis. We found that a MAP < 70 mmHg (relative risk [RR] 9.52, $p = 0.013$) and an AGT grade > 3 (RR 6.56, $p = 0.039$) were univariate factors that predicted the need for intervention. After multivariate analysis, a MAP < 70 mmHg was an independent factor that predicted the need for intervention (Table 4).

Discussion

Adrenal trauma is a rare injury that lacks a typical presentation. Because of its rarity, AGT has attracted limited attention. Since the development of high-resolution CT, AGT has been identified more frequently. The incidence of AGT ranges from 0.03 to 4.95 % in all trauma patients [2, 3]. In our series, we observed a 0.22 % incidence of adrenal trauma. Because the adrenal gland is protected by surrounding organs, cases of isolated AGT are rare

Table 3 Comparison of the therapeutic intervention, non-therapeutic intervention, and observation groups with extravasated adrenal gland trauma

	Therapeutic intervention group ($n = 9$)	Non-therapeutic intervention group ($n = 13$)	Observation group ($n = 10$)	p value
Age (years)	28.7 ± 13.1	28.5 ± 14.3	24.1 ± 8.1	0.639
Gender (male, %)	7, 77.8	10, 76.9	9, 90	0.693
SBP (mean ± SD)	82.6 ± 43.3[a]	113.9 ± 22.1	109.7 ± 11.0	**0.034**
MAP (mean ± SD)	60.0 ± 33.3[a]	85.7 ± 20.9	79.5 ± 10.5	**0.044**
RTS (mean ± SD)	6.0 ± 1.5	7.1 ± 1.2	7.2 ± 0.6	0.063
Associated injuries				
Lung (n, %)	5, 55.6	3, 23.1	6, 60.0	0.147
Pneumothorax (n, %)	6, 66.7	7, 53.8	4, 40.0	0.507
Liver (n, %)	7, 77.8	8, 61.5	9, 90.0	0.287
Spleen (n, %)	2, 22.2	2, 15.4	1, 10.0	0.764
Kidney (n, %)	5, 55.6	7, 53.8	4, 40.0	0.745
AIS—chest	3.1 ± 1.5	2.6 ± 1.8	2.6 ± 1.8	0.767
AIS—abdomen	2.8 ± 1.1	3.8 ± 1.0	3.2 ± 0.9	0.087
ISS (mean ± SD)	33.4 ± 17.0	31.9 ± 13.7	28.5 ± 10.9	0.731
NISS (mean ± SD)	34.8 ± 16.0	34.7 ± 11.7	31.0 ± 9.9	0.741
Hematoma size (cm)	8.8 ± 3.9	8.0 ± 3.4	6.5 ± 2.4	0.300
Adrenal trauma grade				
≤III (n, %)	2, 22.2	7, 53.8	8, 80.0	**0.042**
>III (n, %)	7, 77.8[a]	6, 46.2	2, 20.0	

Bold values are statistically significant ($p < 0.05$)

[a] The SBP, MAP were lower in therapeutic intervention group than the other two groups. Furthermore, the percentage of adrenal trauma grade > 3 was higher in therapeutic intervention group than the other two with significant difference

SBP systolic blood pressure, *MAP* mean arterial pressure, *RTS* Revised Trauma Score, *AIS* Abbreviated Injury Scale, *ISS* Injury Severity Score, *NISS* New Injury Severity Score

Table 4 Analysis of the need for intervention in extravasated adrenal gland trauma

	Relative risk	95 % Confidence interval	p value	Multivariate analysis
Hematoma size				
>6.35 vs. ≤6.35 cm	3.82	0.65–22.45	0.235	–
Adrenal trauma grade				
>3 vs. ≤3	6.56	1.10–39.32	**0.039**	0.054
SBP				
≤90 vs. >90 mmHg	1.78	0.33–10.00	0.654	–
MAP				
≤70 vs. >70 mmHg	9.52	1.64–55.56	**0.013**	**0.011**
ISS				
>16 vs. ≤16	0.33	0.03–2.83	0.557	–

Bold values are statistically significant ($p < 0.05$)

ISS Injury Severity Scale, *AAST* Adrenal trauma grade, *SBP* systolic blood pressure

(approximately 4–7 % of cases) [3, 4, 8, 9]; in this series, the rate of isolated AGT was 5 %.

The mechanism of AGT hemorrhage is still unclear; there are several hypotheses for the possible mechanisms [6, 11, 12]. First, acute hemorrhage may be related to the increased adrenal venous pressure caused by compression of the vena cava during impacting forces. A second explanation is that hemorrhage is the result of a deceleration force, causing the small branches of the adrenal vessels to break. A third explanation is that the adrenal gland has a rich arterial supply that is critically dependent on a single vein. In response to a stressful trauma, catecholamine secretion increases; this increase stimulates the adrenal arterial blood flow, exceeding the limited venous drainage capacity and leading to hemorrhage.

In this series, we found a high incidence of extravasation in AGT. Approximately, 52 % of the patients had extravasation by abdominal CT. Compared with the previous series, this incidence was high [3, 4]. In the extravasated group, the patients had a higher injury grade accompanied by more severe associated injuries and a higher ISS and NISS. All of these results imply that the presence of extravasation in AGT indicates a more severe mechanism and a greater-force impact to the trunk compared with cases of non-extravasated AGT [2].

The severe trauma mechanism and force result in more organ involvement, and severe injury further leads to prolonged ICU and hospital stays. In our study, we expand the importance of AGT as a marker of multiple organ injuries, especially in patients with extravasation [3, 4]. Our findings indicate the need for further evaluation of possible associated injuries.

For the 32 patients with extravasated AGT, we performed 5 laparotomies and 17 angiographies. We identified 4 patients with angiographic extravasation who required further embolization. Only 9 patients had extravasated AGT that required definite management to achieve hemostasis (9/32, 28.1 %). With the use of CT in trauma patients, extravasation was equally as important as active hemorrhage, which needs to be managed. However, some published studies have reported that extravasation in a specific organ can be managed conservatively [13]. There are no previous reports on the management of extravasation in AGT. In this report, we found that only 28.1 % of patients with extravasated AGT required further intervention. Most of the patients could be managed conservatively if they were hemodynamically stable after proper resuscitation. This result implies that AGT is a relatively benign trauma, and conservative treatment can be considered as the primary option in stable AGT patients [4]. Therefore, extravasation is not the only indication for intervention in AGT. We formulated some hypotheses about this result. First, according to the mechanism of AGT hemorrhage, we suspected that some contrast extravasation cases were related to venous bleeding, which might not be detected in angiography. Second, the adrenal arteries have a small caliber, and most of them divide into 10–50 smaller branches over the capsule. The small calibers of these vessels may cause them to occlude and thrombose when angiography is performed, making them undetectable by angiography. Third, cannulation is difficult after structure torsion of a space-occupying hematoma, which makes it more difficult to be identified in angiography. Therefore, we had a high rate of negative angiography findings in extravasated AGT. However, because of the small size of the hemorrhage, we could still resuscitate the patients and place them in the ICU for close monitoring. The explanation may be that although extravasation was found in AGT, conservative management could be applied in cases of extravasation in AGT with good results.

Because of the rarity and diversity of the clinical presentation and prognosis of AGT, an algorithm or consensus for AGT has not yet been determined. We found that many patients presented with an extravasation in their abdominal CT. However, nearly half of the patients did not need further intervention for their AGT. It is necessary to identify patients who need further intervention. In comparing the intervention and conservative groups, initial low blood pressure and high AGT grade were related to the need for intervention. We performed multivariate analysis and identified that a MAP $\leq$ 70 mmHg in extravasated AGT cases predicted the need for intervention (Table 4). There are reasonable indicators that, although extravasation occurs in some cases of AGT, hemorrhaging from AGT might be self-limiting as the result of a vessel spasm or tamponade effect after hematoma formation. When profound hemorrhaging precedes the hematoma and induces further coagulopathy, intractable hypotension could result, and further intervention is indicated.

There are several limitations to this study. First, this was a retrospective study, and the selection of the patients could not be randomized. Although all of the data were collected prospectively and the characteristics of the patients were similar and homogeneous, selection and recall bias could not be completely prevented. Another obvious limitation of this study is that the sample size was small, which consequently limited the power to detect statistical significance. To overcome these limitations, our results should be confirmed by future prospective, randomized controlled trials that compare conservative and aggressive protocols.

Conclusion

AGT is a rare injury with a good prognosis. Most AGT patients can be treated conservatively. Extravasation in AGT is not only a sign of hemorrhage but is also an indicator of severe associated injuries. However, extravasation in AGT is not always mandatory for further management. When intractable hypotension is also present, further management should be considered.

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