The Adrenal Gland: An Organ Neglected in Pediatric Trauma Cases

Bahattin Aydogdu[1]*, Mehmet Hanifi Okur[1], Serkan Arslan[1], Mehmet Serif Arslan[1],Hikmet Zeytun[1], Erol Basuguy[1], Mustafa Icer[2], Cemil Goya[3], Ibrahim Uygun[1], Murat Kemal Cigdem[1], Abdurrahman Onen[1], Selcuk Otcu[1]

Purpose: Adrenal gland injury (AGI) caused by trauma may cause bleeding and life-threatening problems in children. The objective of this study was to analyze the prevalence of AGI in final diagnoses of trauma.

Materials and Methods: The records of 458 patients with abdominal trauma (out of a total 8,200 pediatric patients with trauma of any sort), who were referred to our clinic between January 2009 and July 2014, were reviewed retrospectively. The numbers of patients with AGI and their ages, gender, trauma patterns, affected organs, pediatric trauma scores (PTSs), and injury severity scores (ISSs) were recorded, as well as the associated ultrasound (US) and tomographic scan data, treatments, and complications. Computed tomography (CT) scans obtained after trauma were subjected to both primary and secondary evaluation.

Results: In total, 28 patients with AGI were detected; their average age was 8.54 ± 4.09 (3–17) years. Twenty (71%) patients were male and 8 (29%) were female. Nineteen (68%) patients had fallen from heights; the most commonly injured organs were the kidneys, spleen, and lungs. Injuries were right-sided in 26 (92.9%) patients. The mean ISS was 13.2 (range 5–50) and the mean PTS 8.6 (range 0–11). Seven patients had ISS > 16 and nine had PTS < 8. AGI was diagnosed by CT in 14 (50%) patients and in 3 (9%) by US at primary evaluation. Upon secondary scan inspection focusing on the possibility of adrenal gland injury, such injury was ultimately detected in 28 patients. All patients underwent conservative follow-up, and one died.

Conclusion: We recommend calculation of the PTS, as well as other trauma scores, when pediatric patients suffering multiple or blunt abdominal trauma(s) present to the emergency . In addition, we believe that in children with trauma involving the liver, spleen or kidneys, careful evaluation using a CT scan would increase the diagnosis of AGI and reveal a realistic rate of AGI in trauma cases.

Keywords: adrenal gland injury; blunt abdominal trauma; diagnosis; pediatric; prevalence.

INTRODUCTION

Post-traumatic adrenal gland injury (AGI) was first identified by Canton in 1863.[1] The rate of adrenal injury following abdominal and thoracoabdominal trauma in children is 1–4.95%.[2,3] Computed tomography (CT), ultrasound (US), and magnetic resonance imaging (MRI) have been used to diagnose AGI.[4,5] CT is the preferred modality.[6] Severe adrenal gland bleeding may develop because the gland has a complex vascular structure.[7] Adrenal failure has been reported in some cases after bilateral adrenal injury.[8] Complications of AGI are often quickly followed by death and are accelerated by any severe trauma to other organs.[9,10]
Injuries to the major organs (liver, spleen, and kidney) are (naturally) prioritized during initial examination of patients with abdominal trauma, and adrenal trauma may be missed, therefore we aimed to study the real prevalence of traumatic adrenal injuries.

MATERIALS AND METHODS

In total, 8,200 pediatric trauma patients (<18 years) were admitted to the emergency clinic of Dicle University Hospital between January 2009 and July 2014. We retrospectively examined the records of 458 patients with blunt abdominal trauma, of whom 28 were ultimately diagnosed with AGI. We excluded patients with non-blunt abdominal trauma. Patient's age, gender, trauma pattern, the extent of AGI, the organs affected by trauma, location of the AGI, and the pediatric trauma score (PTS) and injury severity score (ISS) were recorded (**Tables 1 and 2**). Initial US and CT scans taken in the emergency room (ER) were examined; the grade of injury, the amount of blood transfused (if any), the duration of stay in the intensive care unit (ICU) and clinic, and any complications were noted.
During primary evaluation, we retrospectively analyzed CT images obtained during the first referral. All available radiological diagnostic data were analyzed retro-

[1] Department of Pediatric Surgery and Urology, Medical Faculty of Dicle University, 21280 Diyarbakir, Turkey.
[2] Department of Trauma and Emergency, Medical Faculty of Dicle University, 21280 Diyarbakir, Turkey.
[3] Department of Radiology, Medical Faculty of Dicle University, 21280 Diyarbakir, Turkey.
*Correspondence: Department of Pediatric Surgery and Pediatric Urology, Medical Faculty of Dicle University, 21280 Diyarbakir, Turkey.
Tel.: +90 412 248 8001; GSM: +90 505 234 4010. Fax: +90 412 248 8523. E-mail address: bahattinaydogdu@hotmail.com.
Received September 2016 & Accepted December 2016

Table 1. Baseline characteristics of all patients with adrenal gland injuries

	N=28
Age, years; mean±SD(range)	8.54 ± 4.09 (3–17)
Sex, (male/female)	20 (71)/8(29)
Pediatric trauma score; mean±SD(range)	8.6±2.9(0-11)
Injury severity score; mean±SD(range)	13,2±10.6(5–50)
Intensive care unit, day; mean±SD(range)	4.33±5,1(1-23)
Hospital stay, day; mean±SD(range)	2.54±1.28 (1-5)
Trauma mechanisms, N(%)	
Falls from flat roofed	19 (68)
Motor vehicle injury	8 (28,5)
Falling of an iron mass	1 (3,5)
Associated organ injuries, N(%)	
Kidney	28 (100)
Liver	12(43)
Head trauma	4(14)
Spleen	3(11)
Lung İnjury	3(11)
Femur fracture	3(11)
Pelvis fracture	1(3)
Classification of Adrenal gland injuries, N(%)	
Grade 4	13(46)
Grade 3	8(29)
Grade 2	6(21)
Grade 1	1(4)

spectively during the secondary evaluation. From our analysis, patients with adrenal hemorrhage were identified. All primary evaluations were performed by ER on-call radiologists. Secondary evaluations focusing on AGI were performed by different experienced radiologists who were randomly selected and were blind to each others reports. AGI was scored as recommended by the American Association for the Surgery of Trauma (**Table 2**).

Table 2. Adrenal organ injury scale (The American Association for the Surgery of Trauma)[19]

Grade	Description of injury
I	Contusion
II	Laceration involving only cortex (<2 cm)
III	Laceration extending into medulla (> 2 cm)
IV	>50% parenchymal destruction

All data were analyzed using SPSS ver. 15.0 software (SPSS Inc., Chicago, IL, USA). Continuous variables are shown as means ± standard deviations (SDs) and categorical variables as numbers with percentages (%). Fisher's exact test was used to compare ISSs and PTSs. A p-value < 0.05 was considered statistically significant. Our ethics committee approved the study.

RESULTS

Adrenal hemorrhage was evident in the primary CT scans of 14 (3.1%) of the 458 patients with abdominal trauma. During our secondary evaluation, we re-evaluated all primary scans with particular reference to the possibility of AGI and detected a total of 28 cases. The average patient age was 8.54 ± 4.09 (3–17) years; 20 (71%) patients were male and 8 (29%) were female. The injury patterns were a fall from a height in 19 (68%) patients, motor vehicle traffic accident in 8 (28.5%), and falling of an iron mass in 1. AGI was evident on the left side in 2 (7.1%) (**Figure 1A**) patients and on the right side in 26 (92.9%) (**Figure 1B**). The mean ISS was 13.2 (range, 5–50); the mean PTS was 8.6 (range, 0–11). Seven patients had a ISS > 16 and 9 patients had a PTS < 8; these are the scores that prompted clinical observation. AGI was detected in 3 (0.7%) patients by US and in 14 (3%) by CT during the first examinations of the 28 patients who were ultimately shown to have

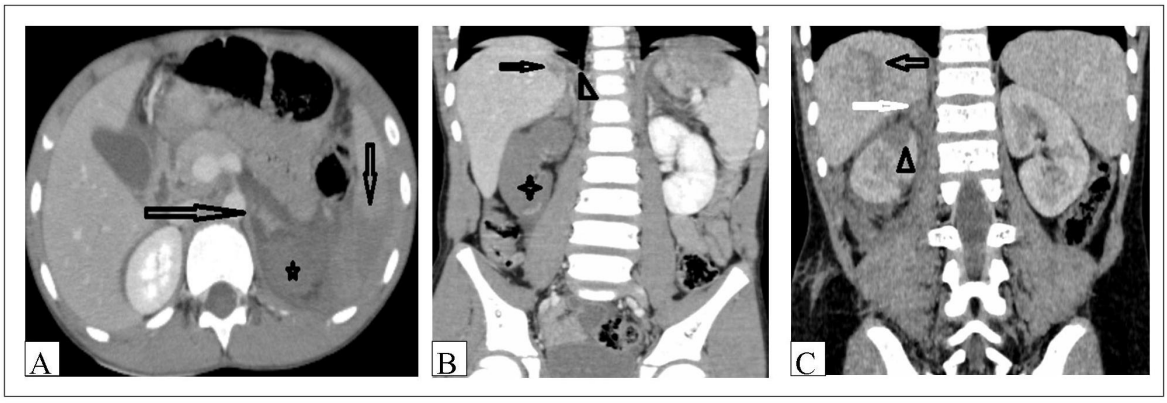

Figure 1. 1A: 10-year-old male patient, after a traffic accident, axial CT images (a. left adrenal injury "horizontal arrow", b. left kidney injury "star" , c. spleen injury "vertical arrow") Respectively. **1B:** 7 -year-old male patient after a traffic accident, coronal CT image (a.Liver injury "horizontal arrow" b. right kidney injury "star" c.Right adrenal "head arrow") Respectively. **1C.** 10-year-old male patient after falling from height, coronal CT image (a.Right adrenal injury "white arrow" b. Right kidneyinjury "head arrow c.liver "black arrow") Respectively.

suffered adrenal hemorrhage after trauma. Fourteen new AGI patients were diagnosed via secondary examination focusing on the adrenal gland (**Figure 1C**). The most common additional organs injured were the kidneys, spleen, and lungs (**Table 1**). Five units of blood were required by four patients; one unit was infused into a patient with grade 4 AGI and grade 3 liver injury; one into a patient with a grade 3 AGI and a grade 5 kidney injury; one into a patient with a grade 1 injury to the left kidney and a grade 4 AGI; and two units into a patient with a grade 3 spleen injury and a grade 2 AGI. One patient with a PTS score of 0 died from multiple trauma. The mean hospitalization durations were 2.54 ± 1.28 (1–5) days in the ICU and 4.33 ± 5.14 (1–23) days in the clinic. Two patients developed renal atrophy and required laparoscopic nephrectomy (without adrenal gland removal) during the follow-up period.

DISCUSSION

AGI may be difficult to diagnose in pediatric cases with multiple organ injuries due to the anatomical location of the gland and the density of surrounding organs. AGI may be diagnosed radiologically, surgically, or at autopsy.[9]

In pediatric trauma series, the rates of AGI were 0.22–1%; we detected AGI in 0.34% of our pediatric trauma patients. CT scans revealed AGI in 3–5% of patients who suffered blunt abdominal trauma.[1] Sevitt et al. reported that adrenal gland hemorrhage was evident in 28% of autopsies on patients who died of trauma.[10] The difference between the live and autopsy rates suggest that AGI may be often missed in life. We therefore re-evaluated the CT scans of patients who suffered abdominal trauma and found that AGI was more common than initially suspected. Injuries to the major organs (liver, spleen, and kidney) are (naturally) prioritized during initial examination of patients with abdominal trauma, and adrenal trauma may thus be missed. If such trauma is carefully considered when evaluating CT scans, the reported rates of AGI may be expected to rise.

Earlier studies found that AGI was most prevalent after blunt (i.e., not penetrating) trauma.[1,11] Our AGI cases had indeed experienced blunt trauma. Earlier studies found that 86–100% of AGIs were on the right side.[2, 3] This may be attributable to the fact that the right adrenal gland vein is shorter than the left and opens more posteriorly into the inferior vena cava, thus rendering the vein more susceptible to high-pressure trauma.[1] AGI was present on the right side of 92.3% of patients in the present study. Although some studies suggested that females suffered more AGIs than did males,[3,8] other studies found the reverse to be true.[2,12] AGI was more common in males than in females in the present study. One-sided (but not bilateral) AGI is rarely associated with clinical symptoms. Even bilateral AGI is seldom associated with acute adrenal failure.[1] Schmidt et al. found that hypertension developed after AGI.[13] None of our patients had bilateral AGI and hypertension was not evident in any case during clinical follow-up.

Although experienced US radiologists may be able to detect a hyperechogenic mass in the adrenal area after trauma, AGI is best diagnosed by abdominal CT, as suggested by an earlier study.[14] MRI is rarely used to detect AGI.[15] When we reviewed the scans of patients with abdominal trauma who had been referred to our ER, AGI was evident in 0.7% of the first US scans and 3% of the first CT scans. Another radiologist evaluated the CT scans of all 458 patients admitted due to abdominal trauma, with particular attention being paid to AGI; AGI was ultimately detected in 28 patients. We attributed the lower rate recorded upon first examination to the fact that clinicians focused more on injuries to the major organs. None of our patients underwent MRI.

The ISS is an anatomical score that reliably predicts trauma severity and mortality, which rises in patients with scores > 16,[16] the frequency of which attained 23.8% in a previous study.[3] In the present study, the rate was 25%, thus consistent with that of the literature. PTS scores that considered adrenal trauma have not been reported in the literature; nevertheless, we calculated PTSs in our present study. A PTS < 8 was associated with higher risks of severe trauma and mortality; the risks were similar to those of patients with a ISS > 16.[16] In total, 32.1% of AGI patients in the present study had a PTS < 8. The difference between the number of patients with a ISS > 16 and PTS < 8 was significant; more patients had a PTS < 8 ($P = .02$). Therefore, we believe that calculation of the PTS is important.

AGI patients have been treated via adrenal gland repair, or partial or total adrenalectomy.[11] Today, neither surgical nor endovascular procedures are commonly used to treat either adult or pediatric patients. However, surgery has been used in a limited number of unstable patients.[10,17] AGI patients, especially those with bilateral AGI, should be monitored for adrenal failure.[3,18] In line with recent practice, all patients were monitored in the ICU for an average of 2.5 days and discharged without surgery after follow-up in the clinic.

CONCLUSIONS

We believe that in children with trauma involving the liver, spleen or kidneys, careful evaluation using a CT scan would increase the diagnosis of AGI and reveal a realistic rate of AGI in trauma cases. Physiological trauma score may be used with other trauma scores, when pediatric patients suffering multiple or blunt abdominal trauma(s) present to the emergency.

CONFLICT OF INTEREST

The authors report no conflicts of interest.

REFERENCES

1. Roupakias S, Papoutsakis M, Mitsakou P. Blunt adrenal gland trauma in the pediatric population. Asian J Surg. 2011;34:103-10.
2. Schwarz M, Horev G, Freud E, et al.Traumatic adrenal injury in children. Isr Med Assoc J. 2000;2:132-4.
3. Figler BD, Webman R, Ramey C, et al. Pediatric adrenal trauma in the 21st century: Children's Hospital of Atlanta experience. J Urol. 2011;186:248-51.
4. Wilms G, Marchal G, Baert A, Adisoejoso B, Mangkuwerdojo S. CT and ultrasound features of post-traumatic adrenal hemorrhage. J Comput Assist Tomogr. 1987;11: 112-5.
5. Iuchtman M, Breitgand A. Traumatic adrenal hemorrhage in children: an indicator of visceral injury. Pediatr Surg Int. 2000;16: 586-8.

6. Sivit CJ, Ingram JD, Taylor GA, Bulas DI, Kushner DC, Eichelberger MR. Posttraumatic adrenal hemorrhage in children: CT findings in 34 patients. AJR Am J Roentgenol. 1992;158:1299-302.
7. Rammelt S, Mucha D, Amlang M, Zwipp H. Bilateral adrenal hemorrhage in blunt abdominal trauma. J Trauma. 2000; 48: 332-5.
8. Asensio JA, Rojo E, Roldán G, Petrone P. Isolated adrenal gland injury from penetrating trauma. J Trauma. 2003;54: 364-5.
9. Stawicki SP, Hoey BA, Grossman MD, Anderson HL 3rd, Reed JF 3rd. Adrenal gland trauma is associated with high injury severity and mortality. Curr Surg. 2003;60:431-6.
10. Sevitt S. Post-traumatic adrenal apoplexy. J Clin Pathol. 1955;8:185-94.
11. Gómez RG, McAninch JW, Carroll PR. Adrenal gland trauma: diagnosis and management. J Trauma. 1993;35:870-4.
12. Lee YS, Jeong JJ, Nam KH, Chung WY, Chang HS, Park CS. Adrenal injury following blunt abdominal trauma. World J Surg. 2010;34:1971-4.
13. Schmidt J, Mohr VD, Metzger P, Zirngibl H. Posttraumatic hypertension secondary to adrenal hemorrhage mimicking pheochromocytoma: case report. J Trauma.1999;46:973-5.
14. Pinto A, Scaglione M, Guidi G, Farina R, Acampora C, Romano L. Role of multidetector row computed tomography in the assessment of adrenal gland injuries. Eur J Radiol. 2006;59:355-8.
15. McGehee M, Kier R, Cohn SM, McCarthy SM. Comparison of MRI with postcontrast CT for the evaluation of acute abdominal trauma. J Comput Assist Tomogr. 1993;17:410-3.
16. Senkowski CK, McKenney MG. Trauma scoring systems: a review. J Am Coll Surg.1999;189:491-503.
17. Igwilo OC, Sulkowski RJ, Shah MR, Messink WF, Kinnas NC. Embolization of traumatic adrenal hemorrhage. J Trauma. 1999 ;47:1153-5.
18. Mehrazin R, Derweesh IH, Kincade MC, Thomas AC, Gold R, Wake RW. Adrenal trauma: Elvis Presley Memorial Trauma Center experience. Urology. 2007;70:851-5.
19. www.aast.org/library/traumatools/injuryscoringscales.aspx