Management of splenic and/or hepatic pseudoaneurysm following abdominal trauma in pediatric patients

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ABSTRACT

Introduction. Splenic and hepatic pseudoaneurysm (PA) is a rare arteriovenous injury that may occur following abdominal trauma. The most frequent complication of PA is late rupture, which can lead to hemodynamic instability. The objective of this study was to describe our experience in the management of visceral PA.

Materials and methods.b A retrospective study of patients under 15 years of age with blunt abdominal trauma associated with splenic and/or hepatic injury treated from 2012 to 2020 was carried out. PA formation and management were analyzed. All patients underwent CT-scan, which allowed trauma grade to be established, and also control contrast-enhanced ultrasonography (CEUS) in the first week following trauma. If PA was confirmed, angiography ± percutaneous embolization were performed.

Results. A total of 32 patients with blunt trauma were included. Mean age was 8.7 ± 3.2 years (2-15 years). 68.7% (n = 22) of patients were male. Median trauma grade was grade III (grades II-IV). 33.3% (n = 5/15) of patients developed splenic PA, and 5.8% (n = 1/17) of patients developed hepatic PA, with mean diagnostic time being 3.7 ± 3 (3-8) days. PA formation was associated with higher severity scores, with a mean difference of 15.6 ± 5.3 (95% CI: 4.37:26.14 p < 0.008). All PA cases – except for one, which required urgent splenectomy – were treated with embolization (85.7%) (n = 5/6).

Conclusions. Visceral PA is underdiagnosed, with an incidence higher than reported. Imaging studies (CEUS) are required prior to discharge in the presence of severe trauma. Treatment remains controversial, but we recommend percutaneous embolization, with splenectomy being reserved for unstable patients.

KEY WORDS: Pseudoaneurysm; Abdominal trauma; Embolization, Contrast-enhanced ultrasonography.

MANEJO DEL PSEUDOANEURISMA ESPLÉNICO Y/O HEPÁTICO DESPUÉS DE UN TRAUMATISMO ABDOMINAL EN PEDIATRÍA

RESUMEN

Introducción. Los pseudoaneurismas (PA) esplénicos y hepáticos son lesiones arteriovenosas raras que se pueden desarrollar tras un traumatismo abdominal. La rotura tardía es su complicación más frecuente que puede conducir a inestabilidad hemodinámica. El objetivo del presente es presentar nuestra experiencia en el manejo de los PA viscerales.

Metodología. Estudio retrospectivo en pacientes < 15 años con traumatismo abdominal cerrado con lesión esplénica y/o hepática, entre 2012-2020. Se analizó el desarrollo de PA y el manejo realizado. En todos los pacientes se realizó tomografía computarizada estableciendo el grado del traumatismo, y estudio control en la primera semana postratumatismo mediante ecografía con contraste (CEUS). Si se confirmaba un PA se procedió a angiograma ± embolización percutánea.

Resultados. Un total de 32 pacientes con traumatismo cerrado, edad media 8,7 ± 3,2 años (2-15 años), 68,7% (n = 22) hombres y mediana de grado de traumatismo grado III (grado II-IV), 33,3% (n = 5/15) desarrollaron un PA esplénico y 5,8% (n = 1/17) desarrollaron un PA hepático con tiempo diagnóstico medio de 3,7 ± 3 (3-8) días. El desarrollo de PA se asoció a mayor puntuación en el índice de severidad con una diferencia de medias de 15,6 ± 5,3 (CI 95% 4,37:26,14 p < 0,008). Todos los PA se trataron mediante embolización un 85,7% (n = 5/6) excepto una esplenectomía urgente.

Conclusiones. Los PA viscerales están infradiagnosticados, con una incidencia mayor a la reportada. Consideramos que un estudio de imagen (CEUS) debe ser realizado previo al alta en los traumatismos severos. El tratamiento sigue siendo controversial: sin embargo, recomendamos la embolización percutánea reservando la esplenectomía para paciente inestables.

PALABRAS CLAVE: Pseudoaneurisma; Traumatismo abdominal; Embolización; Ecografía con contraste.

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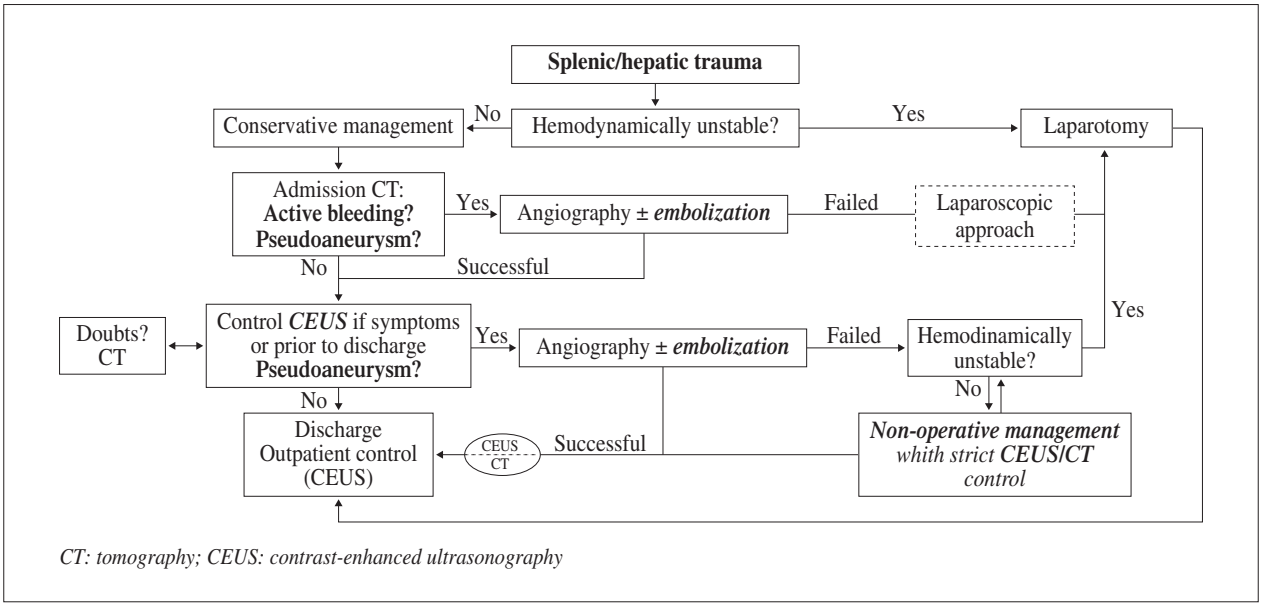

Figure 1. Diagnostic/therapeutic algorithm for blunt abdominal trauma with hepatic and/or splenic involvement.

INTRODUCTION

Pseudoaneurysm (PA) is a vascular injury associated with extraluminal bleeding occurring in the parenchyma of solid organs. This rare arteriovenous injury typically manifests following blunt or penetrating abdominal trauma. However, other etiopathogenic mechanisms such as percutaneous biopsy, intraparenchymal lithiasis, pancreatitis, and previous surgery have also been described.

Incidence is low, with hepatic PA occurring in 1.7% of cases, and splenic PA, in 5.4% of cases[1]. Nevertheless, the actual incidence is estimated to be much higher, with PA potentially present in up to 17% of all solid organ traumas[2]. Visceral PA typically manifests late, which may impair diagnosis in the absence of control imaging tests[2,3].

In PA, there is ongoing communication between vascular and extravascular flow. This creates a high-pressure cavity at the intraparenchymal level, which may result in late organ rupture and subsequent bleeding. However, most PAs are asymptomatic and may go unnoticed. Diagnosis is established by means of imaging tests such as Doppler ultrasonography, contrast-enhanced CT-scan, angiography, and more recently, contrast-enhanced ultrasonography (CEUS)[2,4,5], thus avoiding ionizing radiation. Treatment remains controversial. Conservative management in the hope that it will spontaneously heal, urgent surgery for bleeding control, and selective percutaneous embolization have all been proposed.

The objective of this study was to analyze our experience in the diagnosis and management of visceral PA following blunt abdominal trauma.

MATERIALS AND METHODS

A descriptive, retrospective study of patients under 15 years of age with blunt abdominal trauma associated with splenic and/or hepatic involvement treated over the last 8 years (January 2012-December 2020) in a third-level institution providing care for polytraumatic pediatric patients was carried out.

All patients were initially managed by a cross-disciplinary pediatric team. At admission, intravenous contrast-enhanced CT-scan was performed to establish injury grade according to the AAST (American Association for the Surgery of Trauma) classification. Following initial management, the severity score (Injury Severity Score, ISS) was calculated. In the first week (5-10 days), all patients underwent a new imaging study – formerly Doppler ultrasonography, and since 2016, contrast-enhanced ultrasonography (CEUS) by means of an intravenous SonoVue™ injection through the antecubital vein. SonoVue™ is a second-generation contrast made up of sulfur hexafluoride microbubbles stabilized with a phospholipid and palmitic acid layer. The microbubbles are approximately the size of red blood cells, and they can easily pass through microcirculation. It should be noted that before each test was carried out, authorization and signature of an informed consent form were requested to the guardians given that the use of this drug is still compassionate in this type of injuries[6].

In case of suspected or confirmed diagnosis of PA, angiography for selective or supra-selective percutaneous embolization purposes was carried out, regardless of PA location and size. In patients where embolization was not

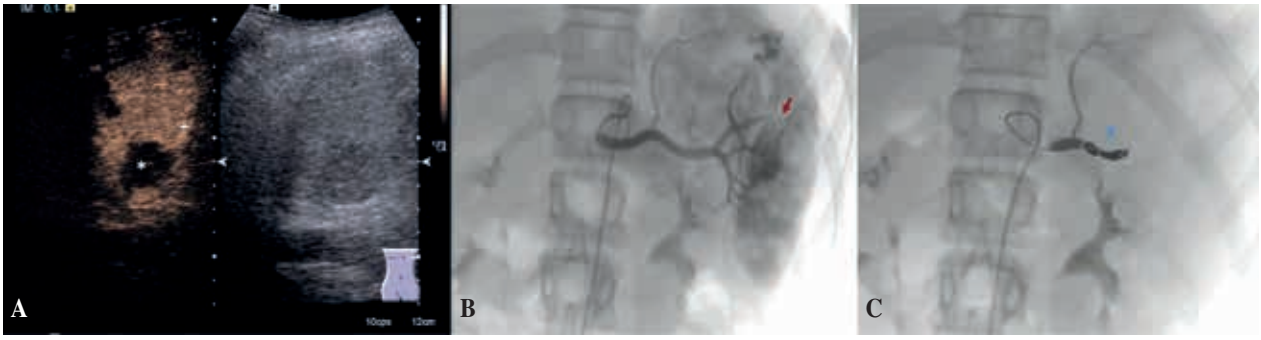

Figure 2. Splenic trauma. A) Contrast-enhanced ultrasonography demonstrating laceration (hypoechoic area*) and pseudoaneurysm. B) Arteriography confirming contrast extravasation. C) Selective percutaneous embolization of the splenic artery with microcoils.

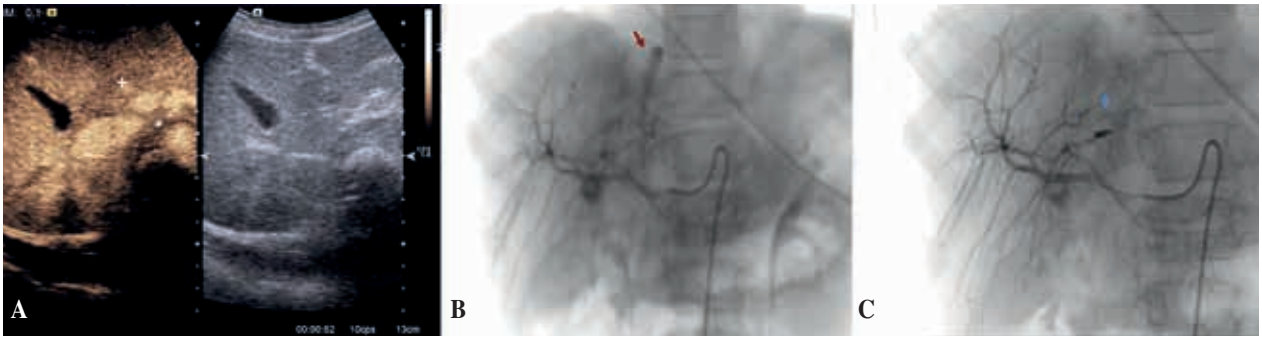

Figure 3. Hepatic trauma. A) Contrast-enhanced ultrasonography demonstrating laceration (hypoechoic area*) and pseudoaneurysm. B) Arteriography confirming hepatic pseudoaneurysm. C) Supra-selective percutaneous embolization of segment II with microcoils.

technically feasible, conservative management with ultrasound controls was decided upon, and in hemodynamically unstable patients, urgent laparotomy was performed. All patients underwent outpatient follow-up with ultrasound controls until full healing (Figs. 1 to 3).

Demographic data, injury mechanisms, initial and definitive management, injury grade according to the AAST classification, severity score (ISS), hospital stay, PICU stay, and treatment results were collected and assessed.

Quantitative variables were expressed as medians (ranges), whereas qualitative variables were expressed through Fischer's exact test. The SPSS v.10 statistical software was used. Statistical significance was established at $p < 0.05$.

RESULTS

A total of 32 patients with blunt trauma associated with hepatic and/or splenic involvement were admitted in our institution over an 8-year period. Of these, 13 had splenic involvement, 15 had hepatic involvement, and 2 had involvement of both organs. Mean age was 8.7 ± 3.2 years (R: 2-15 years), with 68.7% (n = 22) of patients being male. In all cases, CT-scan was performed at admission. Median trauma grade according to the AAST classification was grade III (grades II-IV), and median severity score was 9.5 (R: 9-75). The main injury mechanisms were fall from height (37.5%) (n = 12), fall from standing height (15.6%) (n = 5), direct trauma (21.9%) (n = 7), car accident (15.6%) (n = 5), handlebar injury (6.3%) (n = 2), and crushing (3.1%) (n = 1).

Baseline medical management was carried out in 90.6% (n = 29) of cases. The other patients required selective embolization as a result of intraparenchymal bleeding – 2 splenic traumas and 1 hepatic trauma. No urgent laparotomies were performed at admission.

During admission, 5 splenic PAs and 1 hepatic PA (18.75%) (n = 6/32) were recorded (Table I). When analyzing traumas based on the organ involved, 33.3% (n = 5/15) of splenic traumas and 5.8% (n = 1/17) of hepatic traumas developed PA. Mean diagnostic time was 6.3 ± 1 (6-8) days. 66.6% (n = 4/6) of patients had no symptoms, whereas the other 2 had abdominal pain and low blood pressure. The latter underwent an imaging study, which confirmed active bleeding. One of them underwent embolization, while the other required urgent splenectomy.

PA formation was associated with higher severity scores, with a mean difference of 15.26 ± 5.3 (95%

Table I. Visceral pseudoaneurysm.

ID	*Age (years)*	*AAST injury grade*	*Diagnostic method*	*Diagnostic time*	*Symptoms*	*Treatment*
1	7	Splenic III	US/CECT	7 days	Late bleeding	Splenectomy
2	7	Splenic IV	CECT	5 days	None	Embolization
3	11	Splenic IV	US/CECT	8 days	None	Embolization
4	15	Splenic IV	CEUS	8 days	None	Follow-up
5	12	Splenic III	CEUS/CECT	5 days	None	Embolization
6	9	Hepatic IV	CEUS/CECT	5 days	Pain, low blood pressure	Embolization

AAST: American Association for the Surgery of Trauma; US: ultrasonography; CECT: contrast-enhanced CT-scan; CEUS: contrast-enhanced ultrasonography.

CI: 4.37:26.14 p < 0.008). However, no differences in terms of multiple organ involvement and AAST injury grade (> grade 3) were found, with a mean difference of 0.33 ± 0.5 (95% CI: -0.48:1.14).

All patients diagnosed with PA underwent angiography, except for 1, who was hemodynamically unstable and required urgent laparotomy with total splenectomy as a result of PA rupture and late bleeding. 80.0% (n = 4/5) of patients successfully underwent embolization using the Amplatzer occlusion system (n = 2) and coils/microcoils (n = 3). In 1 case, embolization was not successful, and follow-up was decided upon until PA spontaneously healed.

Mean hospital stay was 7 ± 4 days, without differences in PA patients. However, mean PICU stay was 2 ± 3 days, with PICU stay rates being higher in the PA group – a mean of 3 ± 1 days (95% CI 0.58:5.43 p < 0.17) more. Patients undergoing embolization had no complications.

DISCUSSION

Pediatric abdominal trauma is the main cause of mortality in patients over 1 year old[7], with the spleen and the liver being the organs most frequently involved. Since conservative management of abdominal trauma became the first-line treatment, a series of potentially severe complications, including PA formation[8], have been identified.

PA formation as a complication of abdominal trauma in children has been little discussed, most likely as a result of the low incidence rates reported, the lack of control imaging tests, and the natural progression of PA itself, which potentially includes spontaneous healing[5,9]. Incidence is estimated around 5-13%[8]. However, now that control imaging studies are performed in more healthcare institutions[10], and that conservative management of trauma is gaining traction, incidence is trending higher[8,10,4]. In our series, the overall incidence was higher than reported. The spleen turned out to be the organ most frequently involved, contrarily to other series, where hepatic trauma is typically associated with higher PA formation rates[2]. We believe this is due to the fact our protocol establishes an imaging test is carried out 3-5 days following admission in all traumas ≥ AAST grade III.

In pediatrics, injury grade according to the AAST classification is seemingly not correlated with PA formation[10,11]. In our series, no relationship between injury grade and PA formation was found, probably as a result of most traumas being grade III or IV. However, ≥ 9 post-admission injury severity scores (ISS) – moderate to severe damage – were associated with higher PA formation rates.

Since conservative management has demonstrated to be a successful approach, various authors have called into question the need for control studies, primarily due to the low incidence of late complications, and also to ionizing radiation exposure as a result of CT-scan[4,12,13]. However, various groups recently suggested conducting control studies to rule out complications, including PA formation[1,5,10,11]. As previously stated, in our institution, control studies are carried out in all traumas ≥ grade III. At the beginning of our series, conventional B-mode ultrasonography combined with Doppler ultrasonography used to be the strategy of choice, but today, they have been replaced by CEUS. The fact CEUS is a particularly sensitive technique could partly explain why incidence in our series was higher. Mean diagnostic time was 6 days following trauma, and most patients were asymptomatic, similar to other series[14].

PA treatment remains controversial. Conservative management in the hope that it will spontaneously heal, percutaneous embolization[15,16], and surgery have all been proposed. In our experience, we prefer percutaneous embolization – whenever technically feasible –, because although spontaneous healing is possible[5], the likelihood of PA rupture is high[17], regardless of its size. It can also lead to failed conservative management and require a more aggressive surgical treatment.

Percutaneous embolization did not significantly increase hospital stay in PA cases. However, PICU stay was longer in patients diagnosed with PA, since they were mostly higher grade traumas. No PA cases were identified at outpatient ultrasound/CEUS controls.

CONCLUSIONS

Visceral PA is underdiagnosed, with an incidence higher than reported. In our view, a highly sensitive imaging study without ionizing exposure such as CEUS should be carried out prior to discharge in all moderate to severe traumas, since it allows abdominal organ parenchymal injuries – and their extent – to be assessed. Aside from PA, CEUS also reveals the presence of residual hematoma, bleeding, and non-vascularized areas, even in the absence of symptoms.

PA treatment remains controversial. In our case, we prefer percutaneous embolization as it is effective and safe, with splenectomy being reserved for unstable patients and/or as an alternative of last resort.

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