

# Is spleen-preserving surgery safe for abdominal trauma?

## ¿Es segura la cirugía conservadora de bazo en el trauma abdominal?

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### Abstract

**Background:** Treatment of splenic trauma is currently based on non-surgical treatment or the use of interventional radiology. The conservative surgery of the spleen in splenic trauma remains marginal. **Objective:** To analyze the safety and efficacy of conservative surgical treatment in splenic trauma. **Method:** A retrospective study was performed over a 16-year period with the intention of recording the diagnostic and therapeutic attitude in a second level hospital, focusing on patients who received conservative splenic surgical treatment for splenic trauma, excluding splenectomies and non-surgical treatment. **Results:** 110 patients presented splenic trauma. Spleen-sparing surgery was performed in 15 patients. The grades of splenic lesions were: 1 patient with grade I, 1 patient with grade II, 7 patients with grade III and 6 patients with grade IV. Surgical treatment was splenorrhaphy in 5 patients (33%), hemostatic agents and polyglycolic acid mesh in 4 (26%), partial splenectomy with placement of polyglycolic acid mesh in 3 (20%), partial splenectomy in 2 (13%), and electrocautery in 1 (6%). None of the patients initially treated with conservative surgery required posterior splenectomy and no patient died. **Conclusions:** We provide evidence supporting the usefulness and safety of conservative splenic surgery in splenic trauma, which would have its place in grades II, III and IV trauma in health centers that do not have urgent interventional radiology.

**Keywords:** Abdominal injuries. Splenic rupture. Splenectomy. Hemostatics.

### Resumen

**Antecedentes:** El tratamiento del traumatismo esplénico se basa en medidas conservadoras no quirúrgicas o en el uso de radiología intervencionista. La cirugía conservadora del bazo en el traumatismo esplénico sigue siendo inusual. **Objetivo:** El análisis de seguridad y eficacia del tratamiento quirúrgico conservador en el traumatismo esplénico. **Método:** Se realizó un estudio retrospectivo durante un período de 16 años con la intención de registrar la actitud diagnóstica y terapéutica en un hospital de segundo nivel, enfocándose en los pacientes que recibieron tratamiento quirúrgico conservador esplénico por traumatismo esplénico, excluyendo esplenectomías y tratamientos no quirúrgicos. **Resultados:** 110 pacientes presentaron traumatismo esplénico. La cirugía conservadora esplénica se realizó en 15 pacientes. Los grados de lesiones esplénicas fueron: 1 paciente con grado I, 1 paciente con grado II, 7 pacientes con grado III y 6 pacientes con grado IV. El tratamiento quirúrgico fue esplenorrafia en 5 pacientes (33%), agentes hemostáticos y malla de ácido poliglicólico en 4 (26%), esplenectomía parcial con colocación de malla de ácido poliglicólico en 3 (20%), esplenectomía parcial en 2 (13%) y hemostasia con electrocauterio en 1 (6%). Ninguno de los pacientes tratados inicialmente con cirugía conservadora requirió esplenectomía posterior y ningún paciente falleció. **Conclusiones:** La cirugía conservadora esplénica puede ser útil y segura en traumatismos esplénicos, la cual tendría su lugar en traumatismos de grados II, III y IV en centros hospitalarios en los que no se cuente con radiología intervencionista urgente.

**Palabras clave:** Lesiones abdominales. Ruptura esplénica. Esplenectomía. Hemostáticos.

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## Introduction

The spleen is one of the organs most affected in abdominal traumas. The treatment of abdominal trauma has evolved in the last decade and is currently based on non-surgical treatment, which allows maintaining immune function and the possibility of healing the damaged organ.<sup>1</sup> With this premise in mind, we know that splenectomy is not a harmless procedure, as it is associated with blood loss, several transfusions, and septic complications in the residual splenic cavity, as well as the risk of infection and sepsis after splenectomy due to a compromised immune response.

There is no doubt that the availability of procedures such as percutaneous embolization has allowed a high success rate in non-surgical management.<sup>1</sup> However, in surgical management, splenectomy is established as a fundamental treatment, and techniques such as splenorrhaphy, partial splenectomy, and the use of polyglycolic acid meshes have been relegated to a secondary role.<sup>2</sup> Despite improvements in multidisciplinary protocols<sup>3</sup> and the increased use of percutaneous treatment of splenic trauma lesions, when surgical treatment is required, organ preservation techniques are rarely used. For this reason, the objective of this study is to evaluate and review the number of conservative surgical treatments for splenic trauma in a secondary-level hospital from 2003 through 2019.

## Method

This was a retrospective study that reviews the health records of all patients treated in the ER for abdominal trauma at Hospital Clínico San Cecilio in Granada, Spain. The diagnostic-therapeutic approach was recorded from January 2003 through December 2019 at a secondary-level hospital, focusing on adult patients on conservative surgical treatment for splenic trauma.

Patients were categorized by the degree of hemodynamic stability according to Advanced Trauma Life Support (ATLS) guidelines,<sup>4</sup> evaluating blood pressure, Glasgow Coma Scale,<sup>5</sup> and respiratory rate, as well as grading the severity of injuries according to the American Association for the Surgery of Trauma (AAST),<sup>6</sup> which establishes 5 different grades of injury severity from minor to major.

The care pathway established for a hemodynamically unstable polytraumatized patient (blood pressure < 90 mmHg, profuse sweating along with tachycardia,

cold skin, weak radial pulse, tachypnea, and oliguria) was exploratory laparotomy. When the patient was hemodynamically stable with a negative abdominal examination, ultrasound or abdominal computed tomography (CT) was considered, and based on the results, conservative treatment in the intensive care unit for 48/72 hours was indicated, with serial blood tests and bed rest for 3 to 5 days. If during this period or during admission, the patient exhibited clinical worsening or hemodynamic instability, the imaging modality was repeated, or surgical exploration indicated.

Although the new guidelines<sup>7</sup> consider embolization as the main treatment along with non-surgical treatment, the purpose of this review was only to study conservative splenic surgery. For this reason, we did not include it in any of the possible treatment branches, as at the time of the study, emergency interventional radiology was not available on a 24/7 basis, a situation that has since changed.

A total of 110 adult patients (90 men and 20 women) with splenic trauma requiring admission and various therapeutic approaches were collected. Of this population, 15 patients (13 men [86.7%] and 2 women [13.3%]) required emergency surgery with spleen preservation as initial treatment (Fig. 1). We considered conservative surgery to include partial splenectomies, splenorrhaphy, the use of hemostatic agents and absorbable meshes, or a combination of various techniques. In these 15 patients, the mean age was 28.83 years.

The diagnosis of injuries was established by ultrasound or CT, as recommended by the World Society of Emergency Surgery (WSES) guidelines,<sup>7</sup> except in one patient who required emergency laparotomy without being able to perform a previous imaging modality.

Serial blood tests were performed during the patients' admission, at a rate of 48-72 hours, and all patients underwent a follow-up abdominal CT before hospital discharge, confirming organ viability and the absence of complications derived from surgery.

Descriptive statistics were performed, calculating measures of central tendency and dispersion, and frequency calculations, using the statistical software R (Bell Laboratories, Free Software Foundation).

## Results

The most frequently performed conservative surgical treatment was splenorrhaphy (5/15 patients [33%]).

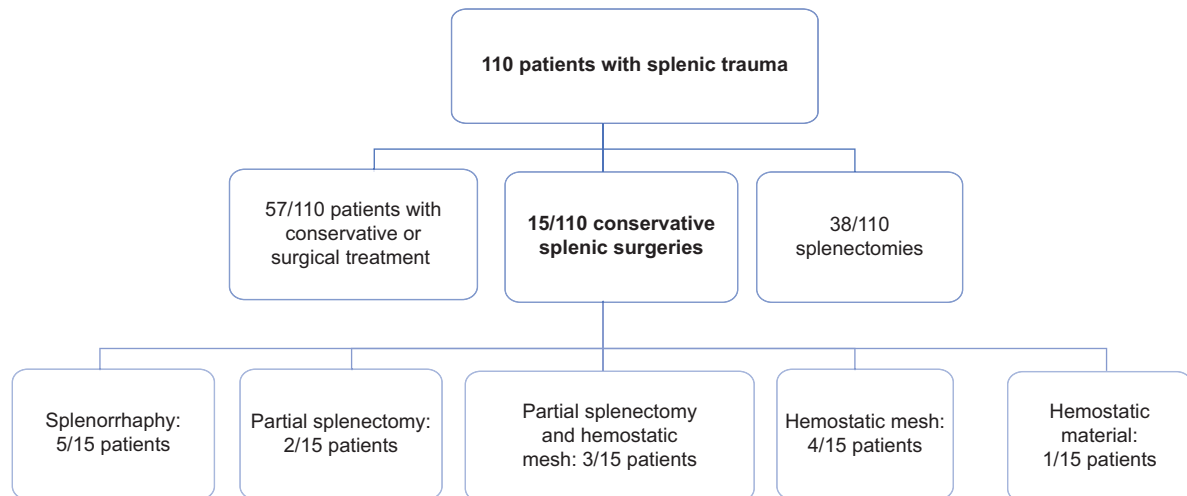


**Figure 1.** A total of 110 adult patients with splenic trauma required admission and various therapeutic approaches. Fifteen patients required emergency surgery, with spleen-conserving surgery as initial treatment. The number of patients and the different therapeutic approaches are shown.

In the remaining patients, hemostatic agents, and placement of polyglycolic acid mesh were used in 4 (26%) cases, partial splenectomy with polyglycolic acid mesh placement in 3 (20%) cases, partial splenectomy in 2 (13%) cases, and hemostasis using electrocautery and hemostatic material in 1 (6%) case. The median length of stay was 11 days (mean, 17.1 days). Out of the total 15 evaluated patients, only 53.3% (8/15) exhibited single splenic injuries, while the remaining 46.6% (7/15) had other associated thoracoabdominal injuries.

The grades of splenic injuries according to AAST were: 1 patient with grade I, 1 patient with grade II, 7 patients with grade III, and 6 patients with grade IV (Table 1); no patient had grade V. In all patients, the injury was due to closed abdominal trauma.

Regarding general patient complications, the formation of intra-abdominal collection in the partial splenectomy or splenorrhaphy cavity occurred in two patients. Specific re-intervention was not required for intra-abdominal complications regarding partial splenectomy, but one patient developed evisceration and required re-intervention to close the abdominal wall.

Adhering to the specific complications of each technique, one patient with splenorrhaphy presented with an intra-abdominal collection, which resolved with antibiotic therapy, and another patient who underwent partial splenectomy with placement of absorbable polyglycolic acid mesh who required antibiotic therapy and radioguided puncture for an infected hematoma at the site of partial splenectomy.

None of the patients initially treated with conservative surgery required subsequent splenectomy, and no patient died.

Regarding surgical technique, in cases where splenorrhaphy was decided, the technique involved identifying and visualizing the laceration area after hemostasis control. To facilitate lesion exposure and achieve better repair, the splenocolic and phrenosplenic ligaments were released. Suturing was performed directly or using pledgets onto which the knot was tied and compressed. Simple drainage (Penrose) or suction (Jackson-Pratt, Blake, etc.) was placed in all patients. The material for splenorrhaphy was either 2.0 gauge silk, or 2.0 gauge polyglycolic acid suture.

Regarding partial splenectomy, selective ligation of polar vascular pedicles was performed when there was laceration at this level. Sometimes, the lesion acted as its own section axis through which the traumatized splenic fragment was resected. If the lesion involved the splenic hilum, partial splenectomy was not feasible, and total splenectomy was required.

Partial splenectomy can be associated with the placement of an absorbable polyglycolic acid mesh (Dexon mesh®). This technique involves placing an adaptable mesh that conforms to the spleen's contour. A continuous suture of the mesh is usually performed, introducing the spleen inside of it while pulling the suture ends until the mesh conforms to the splenic contour. The objective of this prosthesis is to provide enough compression to stop the bleeding without

**Table 1. Characteristics and comorbidity of treated patients**

| Patients | Age, years | Sex | Trauma | AAST grade | Treatment                                      | Length of stay, days | Associated injuries                                                                                                                                                          | Morbidity                                                                                   |
|----------|------------|-----|--------|------------|------------------------------------------------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| 1        | 26         | M   | Closed | III        | Splenorrhaphy                                  | 11                   |                                                                                                                                                                              |                                                                                             |
| 2        | 72         | M   | Closed | II         | Splenorrhaphy                                  | 9                    | Omental laceration<br>Mesosigmoid laceration                                                                                                                                 |                                                                                             |
| 3        | 58         | M   | Closed | III        | Splenorrhaphy                                  | 7                    | Gastroepiploic artery laceration                                                                                                                                             |                                                                                             |
| 4        | 24         | M   | Closed | III        | Splenorrhaphy                                  | 6                    |                                                                                                                                                                              |                                                                                             |
| 5        | 28         | F   | Closed | IV         | Splenorrhaphy                                  | 27                   |                                                                                                                                                                              | Post-splenorrhaphy collection, conservatively managed with antibiotic therapy.              |
| 6        | 36         | M   | Closed | IV         | Partial splenectomy                            | 18                   | Fractures of 4 <sup>th</sup> , 5 <sup>th</sup> , and 6 <sup>th</sup> left ribs<br>Left hydropneumothorax<br>Retroperitoneal hematoma<br>Right subtrochanteric femur fracture |                                                                                             |
| 7        | 15         | M   | Closed | IV         | Partial splenectomy                            | 9                    |                                                                                                                                                                              |                                                                                             |
| 8        | 37         | M   | Closed | III        | Partial splenectomy and polyglycolic acid mesh | 38                   | Grade III left renal laceration<br>Duodenal hematoma                                                                                                                         | Overinfected hematoma at the site of partial splenectomy<br>Required radioguided puncture   |
| 9        | 20         | M   | Closed | IV         | Partial splenectomy and polyglycolic acid mesh | 25                   | Left pleural effusion<br>Grade II renal laceration                                                                                                                           | Pleural effusion requiring thoracentesis                                                    |
| 10       | 15         | M   | Closed | IV         | Partial splenectomy and polyglycolic acid mesh | 10                   |                                                                                                                                                                              |                                                                                             |
| 11       | 43         | M   | Closed | III        | Polyglycolic acid mesh                         | 41                   | Left clavicle fracture<br>Fractures of 3 <sup>rd</sup> to 7 <sup>th</sup> left ribs<br>Left hydropneumothorax                                                                | Left hemopneumothorax requiring chest tube placement for 1 month due to respiratory failure |
| 12       | 26         | M   | Closed | III        | Polyglycolic acid mesh                         | 11                   |                                                                                                                                                                              |                                                                                             |
| 13       | 34         | M   | Closed | IV         | Polyglycolic acid mesh                         | 10                   |                                                                                                                                                                              |                                                                                             |
| 14       | 17         | F   | Closed | III        | Polyglycolic acid mesh                         | 12                   |                                                                                                                                                                              |                                                                                             |
| 15       | 28         | M   | Closed | I          | Hemostatic agent                               | 23                   | Grade II liver injury in segment VII<br>Right pleural effusion                                                                                                               | Right pleural effusion requiring thoracentesis<br>Evisceration                              |

AAST: American Association for the Surgery of Trauma.

triggering organ ischemia. This polyglycolic acid mesh encircling can also be performed independently without the need for partial splenectomy.

Finally, a different technique is simple hemostasis revision with an electrosurgical unit or by applying hemostatic materials such as Floseal® (hemostatic

matrix with gelatin and human thrombin) or Tachosil® (composed of fibrinogen and thrombin on the surface of a collagen sponge).

## Discussion

Single splenic injury represents up to 42% of all abdominal traumas and is associated with a mortality rate ranging from 7 up to 18% in adults.<sup>9</sup> In the last 20 years, there has been a shift in the approach to splenic trauma, favoring non-operative vs more aggressive approaches.<sup>9</sup> Increased availability and advances in radiodiagnostic techniques have contributed to the development of non-surgical treatments with good results. Arterial embolization in severe splenic injuries has reduced the rate of splenectomies<sup>10</sup> and decreased the percentage of emergency surgeries from 33.3% down to 11.9%.<sup>11</sup> Surgical treatment has not shown this evolution in recent years, and organ preservation has been increasingly sidelined, and its use or casuistry has prompted discussion.<sup>12-14</sup>

Splenorrhaphy is rarely adopted as initial surgical treatment, only in around 6% of cases.<sup>15</sup> However, as described by Feliciano et al.,<sup>16</sup> the interest in preserving the spleen in adults arose from the good results of splenorrhaphy in children during the 1970s, to avoid the risk of infection after splenectomy. Despite being a beneficial surgical technique, the safety of splenorrhaphy has always been questioned, as described by Beal and Spisso,<sup>17</sup> who indicate that the risk of re-bleeding may require further surgical intervention, either with splenectomy or with a high transfusion rate until clinical stability is achieved.

In closed trauma, grade III and IV injuries predominate in conservative surgery, while grade I, II, and some grade III injuries are amenable to non-surgical treatment.<sup>18,19</sup>

In direct penetrating traumas, if there is no involvement of the splenic hilum, conservative spleen surgery is also possible,<sup>20,21</sup> with more heterogeneity regarding AAST grades.

Conservative splenic surgery would not be indicated in grade V injuries, previous splenic diseases, coagulation disorders, or in the presence of other intraperitoneal injuries and hemodynamic instability of the patient. In this case splenectomy is the go-to treatment.<sup>22</sup>

Derived from these indications, conservative splenic surgery could also be extrapolated when non-surgical treatment fails.<sup>23</sup> However, controversy surrounds the definitions of non-surgical treatment

failure, indications for angioembolization in special populations (elderly, concomitant brain injuries, etc.), or penetrating traumas.<sup>24</sup> Precisely based on these indications and controversies, attempts have been made to establish protocols to determine when conservative organ surgical treatment should be considered, despite the lack of precision and consensus on its indications.<sup>7,18,25</sup>

Reviewing the literature and based on studies from similar-level hospitals, Harbrecht et al.<sup>26</sup> drew a comparison between various first and second-level hospitals and found that patients treated in second-level hospitals (n = 772) had a higher rate of surgical treatment (38.2% vs 30.7%), but a shorter mean length of stay (10.1 vs 12.4 days) vs patients from first-level centers (n = 1366), while splenorrhaphy was more frequently performed in level 1 vs level 2 trauma centers, around 10% vs 4%. Comparing it with our series, we present a higher rate of conservative splenic surgery, at 28% (which could be attributed to the absence of interventional radiology available 24 hours a day when the study was conducted), and a similar length of stay, with a median of 11 days.

In our series, the rate of complications attributed to conservative procedures was 13%, including collection in the splenic cavity requiring puncture and evisceration requiring surgical intervention, although these were complications associated with any abdominal surgery and not specific to splenic conservative surgery. If we take this into account, the rate of attributable complications is 10%.

One criticism of our study is that we did not evaluate the percentage and functionality of residual parenchyma. In the study conducted by Eskandarlou and Derakhshanfar,<sup>27</sup> which spanned a period of 3 years with a total of 20 patients undergoing partial splenectomies, they quantified that the recovered splenic tissue was approximately 30% in 9 patients, 40% to 50% in 2 patients, and more than 50% in the remaining ones.

Another controversial aspect of our study is the number of patients, which is very low considering it is a retrospective study of 16 years, during which there was a change in prognosis and treatment in the management of polytraumatized patients. Additionally, it is a second-level hospital that did not consistently offer the possibility of arterial embolization. Additionally, polytraumas from the region were not referred systematically either.

Something we should mention is the tendency for these types of conservative techniques to be

performed by more experienced surgeons, while younger surgeons perform more splenectomies, assuming they have not seen as many partial splenectomies or splenorrhaphies during their training. However, this assessment is not documented in the literature, although it has been reported that splenorrhaphy is the least performed procedure by surgeons dedicated specifically to emergency surgery.<sup>28</sup>

Conservative spleen surgery is not a widely performed procedure and should be performed by expert hands,<sup>12</sup> although we believe it is an optimal procedure that all surgeons should master as a therapeutic arsenal if the situation requires it. Although we do not have experience in this regard, there are new techniques besides laparoscopic approaches, combining splenorrhaphy with hemostatic materials.<sup>29</sup>

Currently, there is consensus on the predominance of non-surgical or embolization treatment in the management of minor AAST injuries. On the other hand, there is also consensus in the case of AAST grade V injuries and in situations of critical patient instability, where splenectomy is the predominant technique. However, there is no unanimous consensus in patients with isolated or multiple splenic trauma with grade III or even grade IV injuries. In these patients, we consider conservative splenic surgery as a valid and safe option. Even the WSES guideline<sup>1</sup> specifies that if a laparotomy is performed, partial spleen preservation is possible. In fact, partial (subtotal) splenectomy or splenorrhaphy are safe and viable alternatives to total splenectomy and can even be performed in high-grade injuries.

In conclusion, we can preserve an optimal number of severely injured spleens, maintaining their function, through conservative surgical treatment; especially in situations where interventional vascular radiology is not available, or if conservative treatment has failed in low and medium AAST grades. Although we have also verified utility and safety when these techniques are performed as initial surgical treatment in later stages, larger multicenter studies using matched patient groups are needed to confirm the viability and safety presented in this article.

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## Conflicts of interest

None declared.

## Ethical disclosures

**Protection of human and animal subjects.** The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

**Confidentiality of data.** The authors declare that they have followed the protocols of their work center on the publication of patient data.

**Right to privacy and informed consent.** The authors have obtained approval from the Ethics Committee for analysis and publication of routinely acquired clinical data and informed consent was not required for this retrospective observational study.

## References

1. Coccolini F, Montori G, Catena F. Splenic trauma: WSES classification and guidelines for adult and pediatric patients. *World J Emerg Surg.* 2017;12:40.
2. Louredo AM, Alonso A, de Llano JA, Díez LM, Álvarez JL, del Riego FJ. Usefulness of absorbable meshes in the management of splenic trauma. *Cir Esp.* 2005;77:145-52.
3. Lladó L, Jorba R, Parés D, Borobia FG, Biondo S, Farran L, et al. Influence of the application of a management protocol in the treatment of blunt abdominal trauma. *Cir Esp.* 2002;72:79-83.
4. ATLS Subcommittee, American College of Surgeons' Committee on Trauma, International ATLS working group. Advanced trauma life support (ATLS®): the ninth edition. *J Trauma Acute Care Surg.* 2013;74:1363-6.
5. Jones C. Glasgow coma scale. *Am J Nurs.* 1979;79:1551-3.
6. Kozar RA, Crandall M, Shanmuganathan K, Zarzaur BL, Coburn M, Cribari C, et al; AAST Patient Assessment Committee. Organ injury scaling 2018 update: spleen, liver, and kidney. *J Trauma Acute Care Surg.* 2018;85:1119-22. Erratum in: *J Trauma Acute Care Surg.* 2019;87:512.
7. Coccolini F, Montori G, Catena F, Kluger Y, Biffi W, Moore EE, et al. Splenic trauma: WSES classification and guidelines for adult and pediatric patients. *World J Emerg Surg.* 2017;12:40.
8. Hady HR, Łuba M, Myśliwiec P, Trochimowicz L, Łukaszewicz J, Zurawska J, et al. Surgical management in parenchymatous organ injuries due to blunt and penetrating abdominal traumas — the authors' experience. *Adv Clin Exp Med.* 2012;21:193-200.
9. El-Matbouly M, Jabbour G, El-Menyar A, Peralta R, Abdelrahman H, Zarour A, et al. Blunt splenic trauma: assessment, management and outcomes. *Surgeon.* 2016;14:52-8.
10. Rosenberg GM, Weiser TG, Maggio PM, Browder TD, Tennakoon L, Spain D, et al. The association between angioembolization and splenic salvage for isolated splenic injuries. *J Surg Res.* 2018;229:150-5.
11. Rebzulli P, Gross T, Schnuriger B, Schoepfer AM, Inderbitzin D, Exadaktylos AK, et al. Management of blunt injuries to the spleen. *Br J Surg.* 2010;97:1696-703.
12. Sánchez Arteaga A, Beltrán Miranda P, Gómez Bravo MA, Pareja Ciuro F. Response to «Management of splenic injuries utilizing a multidisciplinary protocol in 110 consecutive patients at a level II hospital». *Cir Esp.* 2020;98:498-9.
13. Pérez Alonso AJ, Zurita Saavedra M, Gómez Sanchez J, Petrone P. Reply to «Response to management of splenic injuries utilizing a multidisciplinary protocol in 110 consecutive patients at a level II hospital». *Cir Esp.* 2020;98:500-1.
14. Giménez Francés C, Ruiz Marín M, López Morales P, Albarracín Marín-Blázquez A. In relation to "Response to 'Management of splenic injuries utilizing a multidisciplinary protocol in 110 consecutive patients at a level II hospital'". *Cir Esp.* 2020;98:568-9.
15. Garber BG, Mmath BP, Fairfull-Smith RJ, Yelle JD. Management of adult splenic injuries in Ontario: a population-based study. *Can J Surg.* 2000;43:283-8.
16. Feliciano DV, Spjut-Patrinely V, Burch JM, Mattox KL, Bitondo CG, Cruse-Martocci P, et al. Splenorrhaphy. The alternative. *Ann Surg.* 1990;211:569-80; discussion 580-2.
17. Beal SL, Spisso JM. The risk of splenorrhaphy. *Arch Surg.* 1988;123:1158-63.

18. Mitsusada M, Nakajima Y. Protocol for splenic salvage procedures in this era of non-operative management. *Acute Med Surg.* 2014;1:200-6.
19. Roy P, Mukherjee R, Parik M. Splenic trauma in the twenty-first century: changing trends in management. *Ann R Coll Surg Engl.* 2018;100:1-7.
20. Petrone P, Anduaga Peña MF, Servide Staffolani MJ, Brathwaite C, Axelrad A, Ceballos Esparragón J. Evolution of the treatment of splenic injuries: from surgery to non-operative management. *Cir Esp.* 2017;95:420-7.
21. Gill S, Hoff J, Mila A, Sánchez C, McKenney M, Elkbuli A. Post-traumatic splenic injury outcomes for nonoperative and operative management: a systematic review. *World J Surg.* 2021;45:2027-36.
22. Richardson JD. Changes in the management of injuries to the liver and spleen. *J Am Coll Surg.* 2005;200:648-69.
23. Di Saverio S, Moore EE, Tugnoli G, Naidoo N, Ansaloni L, Bonilauri S, et al. Non operative management of liver and spleen traumatic injuries: a giant with clay feet. *World J Emerg Surg.* 2012;7:3.
24. Gómez D, Haas B, Al-Ali K, Monneuse O, Nathens AB, Ahmed N. Controversies in the management of splenic trauma. *Injury.* 2012;43:55-61.
25. Van der Cruyssen F, Manzelli A. Splenic artery embolization: technically feasible but not necessarily advantageous. *World J Emerg Surg.* 2016;11:47.
26. Harbrecht BG, Zenati MS, Ochoa JB, Townsend RN, Puyana JC, Wilson MA, et al. Management of adult blunt splenic injuries: comparison between level I and level II trauma centers. *J Am Coll Surg.* 2004;198:232-9.
27. Eskandarlou M, Derakhshanfar A. Introduction of a simple technique for partial splenectomy in multiple trauma patients. *Iran Red Crescent Med J.* 2013;15:e9072.
28. Birindelli A, Martin M, Khan M, Gallo G, Segalini E, Gori A, et al. Laparoscopic splenectomy as a definitive management option for high-grade traumatic splenic injury when non operative management is not feasible or failed: a 5-year experience from a level one trauma center with minimally invasive surgery expertise. *Updates Surg.* 2021;73:1515-31.
29. Lin HF, Lin KL, Wu JM, Chen SC. Preliminary experience of sandwich repair technique: a new method of laparoscopic splenorrhaphy for high-grade splenic injuries. *Surg Innov.* 2014;21:355-64.