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THE ROLE OF IMAGING IN SPLEEN INJURY MANAGEMENT

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Abstract: *The spleen is one of the most commonly injured organs in the body. Both blunt and penetrative injuries can damage the spleen. It is important to manage splenic injury appropriately to restore functionality and control further damage. In splenic injury management, imaging plays a significant role. It helps to establish the level of the injury and guide the course of treatment. For hemodynamically stable patients, non-operative management is appropriate. Hemodynamically unstable patients must undergo surgery that may include splenectomy to avoid excessive hemorrhage. Imaging helps to ascertain the injury grade, which also determines the action that will be taken. High-grade injuries require operations while low-grade injuries can be managed without a surgical operation. The most commonly used imaging method is computed tomography (CT). There are other imaging techniques that are used for different purposes. FAST, for example, is used to show whether there is internal bleeding.*

Keywords: *Spleen, imaging, hemodynamically stable, hemodynamically unstable, hemorrhage, splenectomy, computed tomography*

1. Introduction

The spleen is the most affected organ in blunt abdominal trauma [12]. [1] estimate that up to 49 % of all visceral injuries in blunt abdominal trauma affect the spleen. According to Hildebrand et al. (2014), the injury rate to the spleen in blunt abdominal trauma is 45%. In the United States, more than 400000 people suffer from spleen injury every year [45]. Patients across all demographics are affected. In children, more than 90% of all splenic injuries are caused by blunt abdominal trauma [25]. Because there are many people with spleen injuries it is necessary to elaborate a review of how

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the condition is managed. Lately, the management of splenic injuries without operation is becoming popular across the world [32]. The method is cheaper and does not result in any other comorbid conditions [37]. This is due to the advancement in technology such as interventional radiology. This is the use of imaging to diagnose and manage diseases and injuries. Imaging is essential to effectively identify and manage injuries to the spleen [33], [40].

2. Functions of the Spleen

The spleen is the biggest lymphoid gland in the human body. It has an important immunity function in the body [9]. It filters out pathogens from the blood and stores lymphocytes. Besides, it recycles old and worn out red blood cells by breaking them down to be used for other purposes [17]. The spleen furthermore is involved in blood clotting by storing and releasing platelets when required. These basic roles are vital in the human body. The spleen, however, is susceptible to injuries making it important to gather insight on injury management.

3. Causes of Injury

The major causes of injury to the spleen are blunt injuries. This is a case where the abdomen is injured by a heavy impact without penetration. Such injuries happen in contact sports, in road accidents, falls, and assault [28]. Penetrative injuries also occur in some circumstances such as surgery. Infections predispose the spleen to rapture as they make it swell. An injury to the spleen can lead to excessive hemorrhage. Such an injury requires careful management as it can be fatal. In the past, exsanguination from the spleen required splenectomy to control [43]. It was the only method that was used before the development of non-operative management [18]. The spleen is removed entirely or partially to control life-threatening loss of blood. The patient lost splenic functions after the operation predisposing him/her to infections. In the contemporary world, however, this procedure is not commonly practiced. This is because of the use of imaging to evaluate the degree of damage and guide appropriate intervention measures [34], [42].

4. Imaging

Computed tomography (CT) scanning is the most commonly used tool of imaging [23]. The technology is accurate and widely accessible to many people. CT scans are used to clearly show damages to the spleen and other organs [27]. Images generated help to make decisions on the requisite intervention. CT also helps to reduce unnecessary laparotomy, enhancing non-operative management of spleen injuries. This method of scanning and management is nonetheless limited to hemodynamically stable patients. Focused abdominal sonography for trauma (FAST) scans is conducted in cases of hemodynamically unstable patients [36]. These are quicker scans that are used to detect free abdominal fluid. Stable and unstable patients require different protocols and techniques to manage [5], [41].

In CT scans, the presence of a blunt injury is indicated by hemorrhage, lacerations, a non-perfused region, vascular injury, and hemoperitoneum [14]. Medical practitioners are trained to identify these indicators as they appear on the images generated. The results of these images and the specific appearance of each of the conditions as mentioned above, may shape the intervention measures to be taken. For example, if the volume of blood in hemoperitoneum is deemed to be excessive, surgical procedures may opt over non-operative interventions. An assessment of these factors also helps to estimate the level of damage to determine the specific treatment options.

5. Injury Scale

In order to manage splenic injuries effectively, it is essential to scale the level of injuries. Scaling helps to ascertain the level of damage, the consequences the injury may have, and the action to be taken. The current grading system was developed by the American Association for the Surgery of Trauma to have a more consistent approach in describing injury and management. The grades are I to V, with an ascendency in severity [29]. The table below shows the scale with injury involved and the criteria.

Table 1

Splenic injury grades according to the American Association for the Surgery of Trauma (AAST)

Grade	Injury	Measures
I	Hematoma	Subcapsular less than 10% of the area of the surface.
	Laceration	The capsular tear does not exceed 1 cm of the parenchymal depth.
II	Hematoma	Subcapsular between 10 and 50% of the total surface area.
		Intraparenchymal with a diameter of less than 5 cm.
	Laceration	Parenchymal depth of between one and three centimeters excluding a trabecular vessel.
III	Hematoma	Subcapsular at least half the total surface area or increasing.
		Intraparenchymal or subcapsular that is shattered.
		Intraparenchymal at least 5 cm in diameter or increasing.
	Laceration	Parenchymal depth of at least three centimeters or including trabecular vessels.
IV	Laceration	Laceration relating segmental or hilar vessels producing major devascularization of more than a quarter of the spleen
V	Laceration	Entirely damaged spleen
	Vascular	Hilar vascular damage which devascularizes the spleen

Note: *Adapted from "Splenic trauma: WSES classification and guidelines for adult and pediatric patients," by Coccolini et al., 2017, World Journal of Emergency Surgery, 12(1), p. 42.*

6. Injury Management

Zarzaurand and Rozycki (2017) report that there are six grades labelled I-IV. Grade I denotes minimal injury, II mild, III moderate, IV severe, V massive, and IV lethal injuries. Grades I and II are considered to be low grades, while IV and V are considered to be high-grade injuries. In cases where a patient has an injury to another organ, grade III is categorized as high [45].

6. Injury Management

CT and FAST scans establish whether a person has a splenic injury or not. Once Imaging is complete and the grade of the injury established, the management of the injury follows [7], [10], [21]. Hemodynamically unstable patients are usually at the highest risk and require immediate surgical operation. Splenic salvage refers to the surgical operation to stop bleeding through techniques such as partial splenectomy [19]. Such procedures are critical because non-operative management strategies would fail such patients and may result in death. Patients with low-grade injuries can be successively managed with non-operative means. Non-operative splenic injury management may also apply to patients with severe injury as they await surgery. The decision of whether the surgery will be ultimately required depends on several factors such as progress shown, the advice of doctors, and the patient's choice.

According to Zarzaur and Rozycki (2017), hemodynamically stable patients who do not require laparotomy for other injuries should not elect for splenic salvage. This is because of the effective non-operative methods that can be applied to manage their conditions. Furthermore, 97% of all splenic surgeries result in splenectomy. This requires a cautious examination of the options a patient has, before deciding on the action to take. Inversely, non-operative management has been reported to have a success rate of about 94% [22]. Those whose condition is not critical but still require surgery had a 10% reduction rate in splenectomy when subjected to non-operative management. This is an embodiment of the effectiveness of these measures in managing splenic injury.

One technique used in splenic injury management is embolization, which refers to the introduction of an embolus to the blood vessels for homeostatic purposes [12]. The embolus can be a physical object or a chemical that blocks the flow of blood. In managing injury to the spleen, embolization may be adopted to control hemorrhage. Once the embolus is introduced to the blood vessel, it induces occlusion, thus controlling the hemorrhage in the spleen [31]. This method can be applied for hemodynamically stable patients averting the need for major surgery. However, it does not guarantee success in avoiding surgery, as other factors may necessitate a surgical operation [13]. This process is heavily reliant on imaging. Radiologists must ascertain the specific vessel that needs to be occluded. Guiding the embolus to the required spot also required the services of a highly skilled radiographer.

Other splenic salvage techniques include the application of a hemostatic agent. The recorded cases in which a hemostatic was applied as a method to salvage the spleen proved successful. In one application, most patients were able to achieve hemostasis without a need for subsequent operations. The agent used was fibrin glue in the mentioned cases [15]. A polyglycolic acid mesh can also be applied to cover the sections of the spleen that are damaged. The method is successful in reducing hemorrhage. In the above methods, imaging is critical to determine the type and location of the injury. After the intervention, imaging is required to observe the failure or success of the operation.

Follow up imaging is another important aspect of non-operative splenic injury management. This is because the healing of a damaged spleen is specific to every case. Many different factors affect how the patient will heal. Follow up is thus important to assess the progress that the patient is making. If there is no significant development after non-operative methods, doctors should consider alternative treatment. Follow up also helps to determine when the patient has fully recovered to cease taking intervention measures. A condition that requires follow up to manage is delayed splenic hemorrhage [44].

7. Failure of Non-operative Measures

It is not always guaranteed that non-operative management strategies will result in the successful restoration of the spleen and its functions. Several factors influence the effectiveness of these intervention measures. The most significant element is the hemodynamic stability of the patient [3], [8], [24]. As a basic tenet, a patient must undergo a surgical operation and possibly splenectomy once imaging results show that he/she is hemodynamically unstable [38], [45]. This is because the patient may die from exsanguination. Any attempt to employ non-operative intervention in a hemodynamically unstable patient is highly likely to be unsuccessful. Another factor that may lead to failure is the grade of the injury. According to Rowell et al. (2017), the rate of failure is 44% and 83% for grade IV and V, respectively. This is because high-grade injuries lead to more damages and more loss of blood, making recovery difficult. More hemorrhage is associated with larger quantities of hemoperitoneum. This can consequently be used as a determinant of the failure of non-operative management strategies [25], [45]. Observation of large quantities of hemoperitoneum should thus be a determinant of an operation.

Splenic vascular abnormalities are another important factor that determines the effectiveness of non-operative management. In case a spleen has vascular abnormalities before an injury, it is more likely that non-operative management will fail [16], [35], [39]. According to Zarzaur and Rozycki (2017), vascular abnormalities increase the likelihood of failure by 40%. Embolization would be effective in such cases to stop bleeding. Another determinant of failure is the concomitant solid organ injury. Patients with other injured organs such as the liver are more likely to succumb to

splenic injury [26]. Where imaging shows that a patient has other injured organs, caution ought to be taken when deciding the treatment method. It is advised that patients with injuries to other organ opt for operations, as non-operative management may not be effective.

Studies indicate that the age of a patient may determine how effective non-operative management will be. Older patient aged 55 and above are more likely to experience failure when compared to younger patients. As a person ages, the body develops more complication and the ability to withstand injuries and infection diminishes. Zarzaur and Rozycki (2017) agree that there are more chances of failure involving older patients. The higher likelihood of failure, nevertheless, does not imply that non-operative management is inappropriate for older patients. It is a safer alternative provided the patient meets the threshold for treatment through this method. The higher rates of failure among older patients cannot be exclusively attributed to the splenic injury. This is because older patients have other complications that may predispose them to fail. As such, the difference in the rate of failure for younger and older patients is acceptable.

8. Health Management after Splenectomy

Hemodynamically unstable patients are best managed through surgical operations. In most cases, the spleen may be removed to prevent excessive loss of blood and death. Post total splenectomy, patients lose all the functions of the spleen. It may also result in other complications such as sepsis [6], [11], [20]. Among the functions lost as related to immunity against pathogens. They are thus susceptible to various infections that would not have otherwise affected them if they had a spleen [4]. Such patients need to be cautious with their health. They need to be observant of any possible infection and consult their physicians on the correct intervention measures. This includes prompt medication to avert serious infections. Vaccinations may also be administered to prevent opportunistic infections from affecting such patients. The vaccines need to be administered carefully, and proper records are taken to ensure that the patient is properly protected [2], [30].

9. Conclusion

The spleen is among the organs in the human abdomen that is most susceptible to injury. Both blunt abdominal trauma and penetrative injuries such as stabs can cause fatal damages to the spleen. Therefore, it is crucial to managing spleen injuries prudently to prevent further damage and to hasten the healing process. Imaging is essential in the management of spleen injuries. It is through imaging that radiologists can understand the type an extent of the damage. This helps to determine the type of treatment administered and management strategy. For hemodynamically unstable patients, the only viable option is surgery. This is because other management strategies

would not effectively control hemorrhage and may result in death. Hemodynamically stable patient, non-operative management is advised.

The discussed methods have been proven to be successful in the past and are often applied a majority of all cases with high success rates. Additionally, patients with low-grade injuries can be managed without surgery. Surgical procedures entail the complete or partial removal of the spleen in a process referred to as splenectomy. This procedure should be the last resort for patients who are unstable, and any other management strategy would fail. Determining the damage level is done through imaging. CT is the most commonly used method of imaging, although others such as FAST can be used. Continuous use of imaging is necessary to monitor the development of the healing of the spleen and establish when no further intervention is required or when it is necessary to change the management tactic used.

References

1. Adibi, A., Ferasat, F., et al: *Assessment of blunt splenic trauma: Which imaging scoring system is superior?* In: *Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences*, 2018, p.23-29.
2. Belli, A. K., Dönmez, et al: *Adherence to vaccination recommendations after traumatic splenic injury.* In: *Turkish Journal of trauma & emergency surgery*, 2018, 24(4), p.337-342.
3. Bessoud, B., Denys, A., et al: *Nonoperative management of traumatic splenic injuries: Is there a role for proximal splenic artery embolization?* In: *American Journal of Roentgenology* ,2006, 186(3), p. 779-785.
4. Boam, T., Sellars, P., et al: *Adherence to vaccination guidelines post splenectomy: A five year follow up study.* In: *Journal of infection and public health*,2017, 10(6), p.803-808.
5. Bodansky, D., Jones, R., et al: *An alternative option in the management of blunt splenic injury*. In: *Journal of surgical case reports*, 2013, rjt061.
6. Chakraverty, S., Flood, K.,et al: *CIRSE guidelines: Quality improvement guidelines for endovascular treatment of traumatic hemorrhage.* In: *Cardiovascular and interventional radiology*,2012, 35(3), 472-482.
7. Coccolini, F., Montori, G., et al: *Splenic trauma: WSES classification and guidelines for adult and pediatric patients.* In: *World Journal of Emergency Surgery*, 2017, 12(1), 40-66.
8. Cornwell 3rd, E. E.: *The role of nonoperative management of the injured spleen.*In: *Journal of the National Medical Association*, 1993, 85(4), 297-300.
9. Elsayes, K. M., Narra, V. R., et al: *MR imaging of the spleen: Spectrum of abnormalities*. In: *Radiographics,*2005, 25(4), 967-982.
10. Federle, M. P.: Splenic trauma: *Is follow-up CT of value?.* In: *Radiology*,1995, 194(1), 23-24.
11. Godbole, P., & Stringer, M. D.:

Splenectomy after pediatric trauma: Could more spleens be saved?. In: *Annals of the Royal College of Surgeons of England*, 2002, 84(2), 106-108.

12. Hagiwara, A., Yukioka, T.,: *Nonsurgical management of patients with blunt splenic injury: Efficacy of transcatheter arterial embolization.* In: *American Journal of Roentgenology*, 1996, 167(1), p. 159-166.
13. Harbrecht, B. G., Ko, S. H., et al. *Angiography for blunt splenic trauma does not improve the success rate of nonoperative management.* In: *Journal of Trauma and Acute Care Surgery*, 2007, 63(1), 44-49.
14. Hassan, R., Aziz, A. A., et al: *Computed tomography of blunt spleen injury: A pictorial review.* In: T*he Malaysian journal of medical sciences*, 2011, 18(1), 60-68.
15. Hildebrand, D. R., Ben-Sassi, et al: *Modern management of splenic trauma*. In: *BMJ*, 2014, 348, g1864.
16. Lakin, R. O., Bena, J. F., et al: *The contemporary management of splenic artery aneurysms*. In: *Journal of vascular surgery*, 2011, 53(4), 958-965.
17. Li, H., Lu, L., et al: *Mechanics of diseased red blood cells in human spleen and consequences for hereditary blood disorders.* In: *Proceedings of the National Academy of Sciences*, 2018, 115(38), 9574-9579.
18. Longo, W. E., Baker, C. C., et al: *Nonoperative management of adult blunt splenic trauma. Criteria for a successful outcome*. In: *Annals of surgery*, 210(5), 626-630.
19. Lucas, C. E.: *Splenic trauma: Choice of management*. In: *Annals of surgery*, 1991, 213(2), 98-113.
20. Malangoni, M. A., Levine, A. W., et al: *Management of injury to the spleen in adults: Results of early operation and observation*. In: *Annals of surgery*, 1984, 200(6), 702-705.
21. Marmery, H., Shanmuganathan, K., et al: *Optimization of selection for nonoperative management of blunt splenic injury: Comparison of MDCT grading systems*. In: *American Journal of Roentgenology,* 2007 189(6), 1421-1427.
22. Melikian, R., Goldberg, S. et al: *Comparison of MDCT protocols in trauma patients with suspected splenic injury: Superior results with a protocol that includes arterial and portal venous phase imaging*. In: *Diagnostic and Interventional Radiology*, 2016, 22(5), 395-399.
23. Murken, D. R., Weis, J. J., et al: *Radiographic assessment of splenic injury without contrast: Is contrast truly needed?*. In: *Surgery*, 2012, 152(4), 676-684.
24. Olthof, D. C.: *Splenic injury diagnosis & splenic salvage after trauma* — Amsterdam, NL: University of Amsterdam, 2014.
25. Olthof, D. C., Van der Vlies, C. H., et al: *Evidence-based management and controversies in blunt splenic trauma*.In: *Current trauma reports*, 2017, 3(1), p. 32-37.
26. Pachter, H. L., Guth, A. A., et al: *Changing patterns in the management of splenic trauma: The*

impact of nonoperative management. In: *Annals of surgery*, 1998, 227(5), p. 708-718.

27. Peters, P. E., Lorenz, R., et al: *Splenic imaging*.In: *Lymphology*, 16(2), p. 90-100.
28. Rafailidis, V., Apostolou, D., et al. *Ultrasonography of the healing process during a 3-month follow-up after a splenic injury.* In: *Ultrasonography*, 2015, 34(3), p. 226-231.
29. Raikhlin, A., Baerlocher, M. O., et al: *Imaging and transcatheter arterial embolization for traumatic splenic injuries: Review of the literature.* In: *Canadian Journal of Surgery*, 2008, 51(6), p. 464-472.
30. Rowell, S. E., Biffl, W. L., et al: *Western Trauma Association Critical Decisions in Trauma: Management of adult blunt splenic trauma – 2016 updates.*In: *Journal of Trauma and Acute Care Surgery*, 2017, 82(4), 787-793.
31. Sclafani, S. J., Shaftan, G. W., et al: *Nonoperative salvage of computed tomography – diagnosed splenic injuries: Utilization of angiography for triage and embolization for hemostasis.* In: *Journal of Trauma and Acute Care Surgery*,1995, 39(5), 818-827.
32. Selim, Y. A. R. M., Albroumi, S. A.: *Initial multidetector computed tomography of blunt splenic injury: Impact on management.* In: *The Egyptian Journal of Radiology and Nuclear Medicine*, 2015, 46(3), 573-580.
33. Singh, A., Kumar, A., et al: *"Beyond saving lives": Current perspectives of interventional radiology in trauma*. In: *World journal of radiology*,2017, 9(4), 155-177.
34. Sinha, S., Raja, S. V. V., et al: *Recent changes in the management of blunt splenic injury: Effect on splenic trauma patients and hospital implications.*In: *The Annals of The Royal College of Surgeons of England*, 2008, 90(2), 109-112.
35. Sivit, C. J.: *Pediatric abdominal trauma imaging: Imaging choices and appropriateness*. In: *Applied Radiology*, 2013 8-13.
36. Stanescu, A. L., Gross, J. A., et al: *Imaging of blunt abdominal trauma*. In: *Seminars in Roentgenology*, 41(3), 196-208.
37. Stassen, N. A., Bhullar, I., et al: *Selective nonoperative management of blunt splenic injury: An Eastern Association for the Surgery of Trauma practice management guideline*. In: *Journal of Trauma and Acute Care Surgery*, 73(5), S294-S300.
38. Theilacker, C., Ludewig, K., et al: *Overwhelming postsplenectomy infection: A prospective multicenter cohort study.* In: *Clinical Infectious Diseases*, 2015, 62(7), 871-878.
39. Uyeda, J. W., LeBedis, C. A., et al: *Active hemorrhage and vascular injuries in splenic trauma: Utility of the arterial phase in multidetector CT.* In: *Radiology*,2014, 270(1), 99-106.
40. Van der Vlies, C. H., van Delden, et al: *Literature review of the role of ultrasound, computed tomography, and transcatheter arterial embolization for the treatment of traumatic splenic injuries*. In: *Cardiovascular and interventional*

radiology,2010, 33(6), 1079-1087.

41. Velmahos, G. C., Chan, et al: *Nonoperative management of splenic injuries: Have we gone too far?.* In: *Archives of surgery*,2000, 135(6), 674-681.
42. Wong, Y. C., Wu, C. H., et al: *Distal embolization versus combined embolization techniques for blunt splenic injuries: Comparison of the efficacy and complications*.In: *Oncotarget*, 2017, 8(56), 95596-95605.
43. Yorkgitis, B. K.: *Primary care of the blunt splenic injured adult*.In: *The American journal of medicine*, 2017, 130(3), 365-e1-365-e5.
44. Zabolotny, B., Hancock, B. J., et al: *Blunt splenic injuries in a Canadian pediatric population: The need for a management guideline*. In: *Canadian journal of surgery*, 2002, 45(5), 358-363.
45. Zarzaur, B. L., Rozycki, G. S.: *An update on nonoperative management of the spleen in adults*. In: *Trauma surgery & acute care*, 2017, 2(1).