



Delayed splenic hemorrhage: Myth or mystery? A Western Trauma Association multicenter study



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ABSTRACT

Background: Multi-detector computed tomography imaging is now the reference standard for identifying solid organ injuries, with a high sensitivity and specificity. However, delayed splenic hemorrhage (DSH), defined as no identified injury to the spleen on the index scan but delayed bleeding from a splenic injury, has been reported. We hypothesized that the occurrence of DSH would be minimized by utilization of modern imaging techniques.

Methods: Data was retrospectively collected from 2006 to 2016 in 12 adult Level I and II trauma centers. All patients had an initial CT scan demonstrating no splenic injury but subsequently were diagnosed with splenic bleeding. Demographic, injury characteristics, imaging parameters and results, interventions and outcomes were collected.

Results: Of 6867 patients with splenic injuries, 32 cases (0.4%) of blunt splenic hemorrhage were identified. Patients were primarily male, had blunt trauma, severely injured (ISS 32 (9–57) and with associated injuries. Injuries of all grades were identified up to 16 days following admission. Overall, half of patients required splenectomy. All index images were obtained using multi-detector CT (16–320 slice). Secondary review of imaging by two trauma radiologists judged 72% (n = 23) of scans as suboptimal. This was due to poor scan quality primary from artifact (23), single phase contrast imaging (16), and/or poor contrast bolus timing or volume (6). Notably, only 28% of scans in patients with DSH were performed with optimal scanning techniques.

Conclusion: This is the largest reported series of DSH in the era of modern imaging. Although the incidence of DSH is low, it still occurs despite the use of multi-detector imaging and when present, is

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associated with a high rate of splenectomy. Most cases of DSH can be attributed to missed diagnosis from suboptimal index imaging and ultimately be avoided.

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Introduction

Blunt splenic injury occurs in approximately 40,000 patients in the United States annually.¹ Selective non-operative management remains the mainstay of therapy in hemodynamically stable patients with blunt splenic injuries.^{2–5} This in part is due to better diagnosis of splenic injuries with the evolution of computed tomography. Imaging has been further advanced with the adoption of multi-detector computed tomography (MDCT) technology.⁶ Advancement in image resolution and speed allows detection of splenic injuries and active hemorrhage⁷ with a sensitivity and specificity reaching 95%.⁸ This, in conjunction with a greater understanding of the pathophysiology of splenic injuries, has resulted approximately 90% of splenic injuries successfully managed non-operatively.^{9–15}

Delayed splenic rupture has been defined as post traumatic splenic bleeding with no splenic injury detected on index imaging.⁷ It has been previously documented in the literature but generally been isolated to case reports and with older scanning technology.^{7,16–18} Because terminology in the literature is confusing, has changed over time, and is not entirely reflective of pathology, delayed splenic rupture is now coined “delayed splenic hemorrhage” (DSH). The primary objective of the current study was to investigate the incidence of DSH. The incidence with modern day MDCT is largely undefined, which prompted us to ask the question if DSH was a myth or mystery?

Methods

The Western Trauma Association Multicenter Trials Committee approved this study and participating centers were drawn from the membership of the Western Trauma Association. All participating centers obtained local IRB approval. This was a retrospective review of adult patients (age > 15) from twelve U.S. Level I and II trauma centers with a diagnosis of delayed splenic hemorrhage after traumatic injury from 2008 to 2016. Delayed splenic hemorrhage is defined as post traumatic splenic bleeding with no splenic injury detected on index imaging. Participating centers included: University of Maryland, R Adams Cowley Shock Trauma Center, University of Texas, Baylor College of Medicine, University of California San Francisco, University of Colorado, Denver, University of California, Fresno, West Virginia University, University of California, Los Angeles County, Oklahoma University, Wesley University and Gundersen Heath. Patients were included in the study only if the admission CT scan of the abdomen was performed using intravenous contrast and demonstrated no splenic injury after review by an attending radiologist. Patients with diffuse hemoperitoneum or perisplenic hematoma were excluded from analysis even if no splenic injury was detectable. Patient demographics, injury mechanism, injury severity score (ISS), associated injuries, management of splenic injury, and outcomes were collected. All patients were subsequently diagnosed with a splenic injury by repeat imaging or operative exploration. Splenic injuries were classified according to the AAST organ injury scale.¹⁹

Imaging data collected included the type and resolution of the CT scanner, volume and timing of intravenous contrast, phase of study and the different phases in which solid organs were imaged.

All index CT scans were reviewed at each respective institution and then subsequently reviewed by one of two board certified dedicated trauma radiologists (R.B. and K.S.) who were blinded to clinical data. Patients with diffuse hemoperitoneum or perisplenic hematoma were excluded after secondary review by the dedicated trauma radiologists if there was concern for missed splenic injury on the first evaluation. Imaging was graded based on scan technique and quality. Scan technique was considered inadequate if there was poor contrast bolus timing or low volume of volume injected, defined as a bolus time less than 4 ml/s or contrast volume less than 100 cc. Scan quality was assessed for attenuation, motion, and artifact.

Results

Over the ten year period of the study, 6867 patients with splenic injuries were screened, of whom 32 (0.4%) met final inclusion criteria (Fig. 1) for evaluation of delayed splenic hemorrhage. Patients were primarily male and severely injured. Twenty-eight of the 32 patients had other thoracoabdominal injuries noted on CT scan including left rib fractures, renal or adrenal injuries suggesting high impact in surrounding organs. Demographics and associated injuries are noted in Table 1. The diagnosis of delayed splenic hemorrhage was made ranging from post injury day 0 to day 16. Nearly half of the patients with DSH occurred within the first 24 h and these included patients with grades I-IV injuries. When reviewing the imaging specifically in the early DSH group, 40% of these scans were deemed high quality (Table 2).

The most common indicators of bleeding that led to the diagnosis of a splenic injury were hemodynamic instability and drop in hemoglobin and hematocrit. DSH was associated with all grades of splenic injury, however the most common grade of injury was grade I (Table 3). Of the 32 patients with DSH diagnosis was made operatively in 14 patients and by repeat CT scan in 16 patients. A total of 16 patients who ultimately underwent intervention, 11 patients underwent splenectomy and 3 patients had splenorrhaphy. Two patients underwent angio-embolization as primary therapy. Sixteen patients with DSH required no further intervention.

Grade I injuries were equally likely to be treated with expectant management versus operative management as were higher grade injuries (Table 4). There were no mortalities directly attributable to DSH, however death occurred in four patients.

Contribution of imaging data

All index images were obtained using multi-detector CT (16–320 slice). Only six of the scanners used were 64 slice or greater, 13 scans were acquired on 40 slice scanners, and 9 scans were acquired on 32 slice scans or less. The type of scanner was unknown in three patients. Index CT scans were secondarily assessed for three different indices of scanning: phase type and number of time points the spleen was imaged, the volume and injection rates of contrast material and scan quality for beam hardening (streak) artifacts arising from adjacent ribs or arms placed next to the torso. The phase type and the number of time points the spleen was imaged during the index scan was variable by

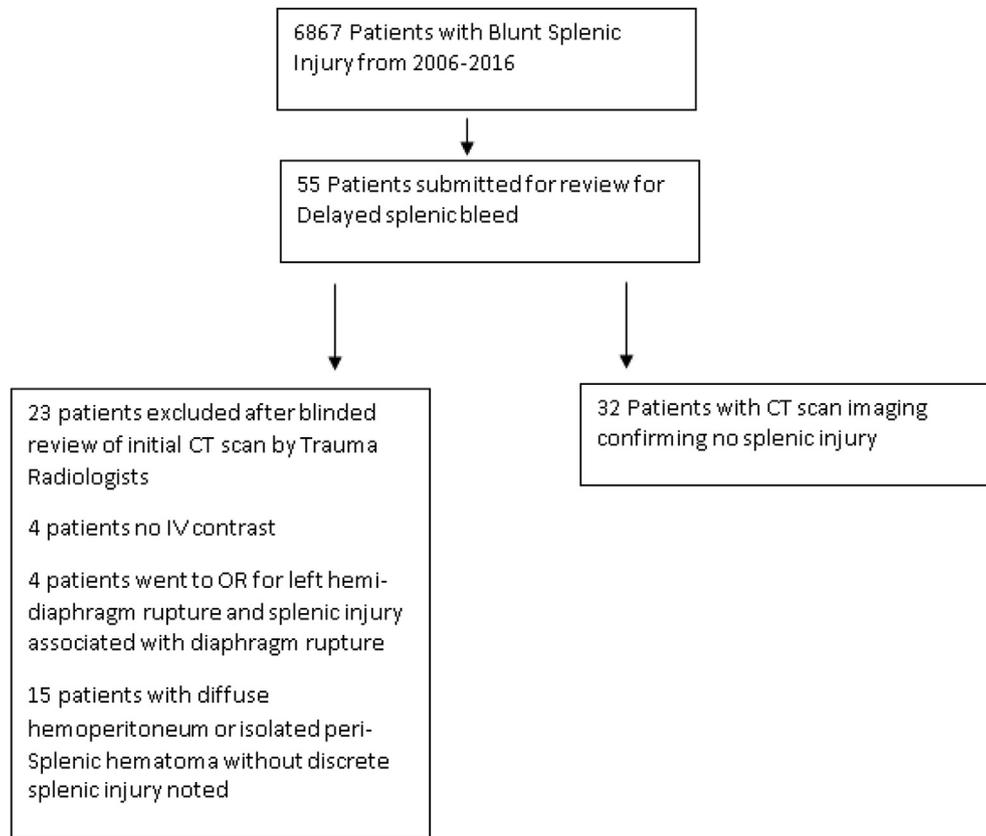


Fig. 1. Inclusion and Exclusion criteria for patients evaluated for delayed splenic hemorrhage.

Table 1
Demographics, injury, disposition.

Age, mean (range)	42.5 (16–79)
Male	25 (78%)
ISS, mean (range)	32 (9–57)
Mechanism of Injury	
Blunt	29 (91%)
Penetrating	3 (9%)
Hospital stay (days)	14
Associated Injuries	
Left rib fracture	10 (31%)
Hemo/pneumothorax	11(34%)
Renal Injury	3 (9%)
Adrenal Injury	1 (3%)
Disposition	
Home	16 (50%)
LTAC	7 (22%)
Rehab	5 (16%)
Death	4 (13%)

Table 2
Grade of splenic injury at time of delayed splenic hemorrhage.

Grade of Splenic Injury (n = 32)	
I	15 (47%)
II	4 (12%)
III	8 (25%)
IV	2 (6%)
V	2 (6%)
Unknown	1 (3%)

Table 3
Timing of delayed splenic hemorrhage.

<48 h	15 (47%)
>48hrs-5 days	8 (25%)
>5–7days	6 (19%)
>7days	2 (6%)
Unknown	1 (3%)

institution (Table 5). The spleen was imaged at a single time point in 19 patients during the portal venous phase and in five patients during only the arterial phase. In the remaining eight patients the spleen was imaged during both the arterial and portal venous phases. Grade I splenic injuries were most commonly missed in patients imaged at a single time point with portal venous phase imaging. Secondary review of images judged 23 (72%) of the scans to have been performed using inadequate techniques for accurate diagnosis of splenic injuries (Table 6). The most common reasons were poor contrast bolus timing (n = 5) and inadequate contrast volume (n = 1), with timing less than 4 ml/s and bolus volume less than 100 ml. Additionally, thirteen of the CT scans were deemed to have poor scan quality, primarily due to beam hardening artifact attributed to arms placed adjacent to the torso. There were only nine scans judged to be of good quality. We defined adequate imaging as no artifact (beam hardening or motion) and adequate contrast timing and volume. Of these nine patients there were grade I-IV delayed splenic hemorrhage identified after having initial imaging that was negative. Of note, only two of these nine scans were performed with both arterial and portal venous phases.

Table 4
Intervention by grade of splenic injury.

N = 32	Splenectomy or Splenorrhaphy	Non-operative Management	Angio Embolization
I	7 (22%)	8 (25%)	
II	2 (6%)	2 (6%)	
III	2 (6%)	3 (9%)	1 (3%)
IV	1 (3%)	1 (3%)	
V	1 (3%)		1 (3%)
Unknown	1 (3%)		

Table 5
Imaging phase for Patients with Delayed Splenic Hemorrhage.

	Portal Venous Phase	Arterial Phase	Dual Arterial and Portal Venous Phase
All Grades	19 (59%)	5 (16%)	8 (25%)
I	10 (31%)	2 (6%)	3 (9%)
II	1 (3%)	1 (3%)	2 (6%)
III	6 (19%)	0	2 (6%)
IV	0	1 (3%)	1 (3%)
V	1 (3%)	1 (3%)	0
Unknown	1 (3%)		

Table 6
Quality of scan by grade of splenic injury.

Grade	Adequate Scan	Inadequate Scan
All Grades	9 (28%)	23 (72%)
I	3 (9%)	12 (38%)
II	3 (9%)	1 (3%)
III	1 (3%)	7 (22%)
IV	1 (3%)	1 (3%)
V	1 (3%)	1 (3%)
Unknown		1 (3%)

Discussion

We report the largest series of delayed splenic hemorrhage in the era of modern imaging. Of 6867 patients with splenic injuries, 32 cases (0.4%) of blunt splenic hemorrhage were identified. Injuries of all grades were identified up to 16 days following admission and importantly, half of the patients underwent splenectomy. To better understand how this entity was occurring with the use of modern multidetector CT scanning, we secondarily assessed all index images for three different indices of scanning: phase type and number; technique, based on contrast bolus timing and volume; and scan quality which included beam hardening or motion artifacts. Several important scan characteristics were identified. First, two-third of cases of DSH were performed using only single phase scanning, primarily the portal venous. Second, 72% of scans were performed using either suboptimal timing or volume of contrast. Third, close to half of the scans were of poor quality predominately from beam hardening artifact when arms were kept adjacent to the torso.

Delayed splenic rupture was first described by Dr. Baudet in 1920 as splenic rupture occurring 48 h or more after injury and was coined the “latent period of Baudet.”^{20,21} In 1966, Sizer et al. reviewed six cases of delayed splenic rupture and found that 80% occurred within 14 days and 95% within 21 days.²² There are case reports, however, of delayed splenic rupture has been reported up to 70 days after injury.¹⁶ The first case in the era of CT imaging was reported in 1981 by Toombs et al., and was characterized as splenic bleeding occurring greater than 48 h after traumatic injury in a patient with an identified splenic injury.²³ Since then there have been a number of additional reports and importantly, the diagnosis refined to now be limited to delayed splenic bleeding in

patients with normal appearance of the spleen on the initial post trauma MDCT.^{8,17} The historic incidence of delayed splenic rupture has been reported to range from 0.3% to 24%.^{7,8,16} Recent literature has been limited to case reports and the true incidence in the current setting of multidetector CT scanning remains unknown.^{7,8,16,22}

Because of confusing and changing definitions of delayed splenic rupture, we chose to refer to this entity as delayed splenic hemorrhage. In the current study, patients were as classified as having DSH if their index CT scan was interpreted as having no evidence of splenic injury but did not stipulate the time to hemorrhage. Importantly, we identified a number of cases of early bleeding.

There have been a number of theories put forth concerning the etiology of DSH. Primarily, this entity has been attributed to a sub capsular hematoma that was not of sufficient size for detection early after injury but subsequently expanded and ruptured.⁸ This is consistent with our data that revealed almost half of our identified cases were Grade 1 splenic injuries. Sub capsular hematomas are an identified risk factor for failure of non-operative management.²⁴

We additionally propose that suboptimal imaging may be responsible for failure to detect splenic injury, including phase type and choice of phase. The importance of dual phase imaging is confirmed in a study by Bosack et al.²⁵ In their retrospective review of 120 blunt abdominal trauma patients who underwent dual phase imaging, they found that the arterial phase was more sensitive and accurate for the diagnosis of splenic pseudoaneurysms while portal venous phase imaging was better for the detection of active bleeding and parenchymal injuries.²⁵ The authors concluded that dual phase CT has better overall diagnostic performance than either single phase CT for detection of splenic trauma.²⁵ Uyeda et al., reviewed 147 patients with traumatic splenic injuries where 59% of vascular injuries were visualized only during the arterial phase, again suggesting that vascular injuries could be missed if single phase portal venous scanning were utilized.⁷ In the current study, approximately three-fourths of patients with DSH had only single-phase imaging, primarily portal venous, which may have led to the missed diagnosis of a splenic injury on the index scan. An alternative or additional explanation for DSH may be the delayed appearance and subsequent rupture of splenic pseudoaneurysms, which remains the rationale for protocols that incorporate follow up scans.²⁶

Imaging artifact was a second etiology of suboptimal scanning which was most affected by patient position. The, “arms at the side”

Arterial and venous phase MDCT
Arms away from the torso
Contrast volume >100cc
Bolus timing >4cc/second

Fig. 2. Recommendations for optimal imaging screening for splenic injury.

position resulted in artifact in one-third of patients. Left sided rib fractures also obscured an adequate view of the spleen in some cases resulting in artifact and obscuring normal contour. When feasible, CT scans should routinely be performed by imaging with the patient's arms overhead allowing for a less inhibited evaluation of the spleen.

There is no consensus in the literature regarding the optimal contrast volume and injection rate that is used for whole-body MDCT. Vascular and parenchymal enhancement can be affected by injection rates and the volume of contrast material used. Nguyen et al. evaluated two different injection protocols using a monophasic injection rate of 4 mL/s using a higher concentration of iodine (100 mL, 400 mg I₂/mL) or a biphasic injection (6 mL and 4 mL/s) with lower concentration of iodine (150 mL, 300 mg I₂/mL) and found similar vascular and parenchymal enhancement could be obtained with a 16-slice whole-body MDCT for imaging patients with polytrauma²⁷. In our study we considered injection rates less than 4 mL/s and volume less than 100 mL contributing factors for suboptimal imaging to demonstrate splenic vascular and parenchymal injuries.

The current study has several strengths including the multicenter nature and large number of patients screened with splenic injuries. However, our methodology is not without limitations. This is a retrospective review of a very rare complication. The true incidence of DSH may be higher than reported as we identified only those injuries that became clinically relevant and led to additional imaging or operation. Scanning interpretation can also be variable. We attempted to control for variation in interpretation by having all index CT scans evaluated by two dedicated trauma radiologists from high volume centers that were blinded to clinical data. Scans that were interpreted by these radiologists as having a splenic injury on index scans were not included in our final analysis. Lastly, the low number of cases of DSH limits definitive conclusion. We intentionally used a very strict definition of injury, excluding all cases of diffuse hemoperitoneum or perisplenic hematoma, as these findings may have been related to a splenic injury.

Conclusion

Despite advances in MDCT technology and availability of high resolution images, DSH still occurs. Most cases can be attributed to suboptimal imaging even at major trauma centers. Based on our findings we recommend dual phase scanning to include both arterial and portal venous phases; contrast injection at >4 cc/second using a volume of at least 100 mL of contrast, and avoidance of scanning with patient's arms placed adjacent to the torso to reduce beam hardening artifacts (Fig. 2). It is important to acknowledge that despite these recommendations, splenic injuries can occur and delayed splenic hemorrhage is a reality.

Financial disclose

We the authors have no financial or professional conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amjsurg.2019.06.025>.

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