Mesenteric Vascular Injury in Trauma: An NTDB Study

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Background: Although abdominal trauma remains a major cause of morbidity and mortality, there has not been a large-scale multicenter study regarding outcomes in patients who incur mesenteric vascular injuries. The goal of this retrospective analysis was to investigate the factors associated with outcomes in patients with trauma diagnosed with mesenteric vascular injuries.

Methods: A retrospective database analysis was performed on patients who sustained a mesenteric vascular injury (MVI, ICD-9 902.20−902.29) identified by the 2012 National Trauma Data Bank. Data were analyzed to identify differences in hospital length of stay, emergency room (ER) and final hospital disposition, and mortality based on patient age, gender, race, Injury Severity Score (ISS), and injury type (blunt or penetrating).

Results: Of the 1,133 total patients included, blunt trauma accounted for 740 (65%) of the injuries, whereas penetrating trauma accounted for 364 of the injuries (32%). Patients with penetrating injuries were 1.43 times more likely to die from their injuries than those suffering from blunt trauma (95% CI 1.04−1.98, $P < 0.05$). Patients with a higher ISS (>16) were 5.39 times more likely to die from their injuries than those with a lower ISS (95% CI 1.89−15.4, $P = 0.002$); if ISS was >25, the patient was 15.1 times more likely to die (95% CI 5.5−41.7, $P < 0.001$). Men were more likely to suffer from penetrating injuries than women (37% vs. 13%, $P < 0.001$), and African Americans were nearly 4 times more likely to present with penetrating injuries (69% vs 17%, $P < 0.001$). Age was also associated with mortality as patients >65 years and between 21 and 44 years were more likely to die from their injuries than patients in other age categories. Of the 740 patients with blunt MVIs, 326 (44%) were taken directly from the ER to the operating room (OR) and 306 (41%) to the intensive care unit (ICU), whereas with penetrating MVIs, 311 (85%) were taken to the OR from the emergency department and 18 (5%) to the intensive care unit. Of the 740 blunt MVIs, 115 died (16%), compared with 76 (21%) of the penetrating MVIs ($P < 0.001$). Injuries to the hepatic and superior mesenteric arteries were associated with higher mortality, with OR 2.03 and 3.03, respectively ($P < 0.001$).

Conclusions: The presence of mesenteric arterial injury warrants rapid identification and management as these injuries are associated with significant morbidity and mortality, with penetrating mechanism, injury to large mesenteric vessels, and increased ISS associated with increased mortality.

INTRODUCTION

Mesenteric arterial injuries are rare, occurring in 1−5% of trauma patients,[1,2] representing a wide array of injury patterns and clinical presentations, from a stable patient with a minor contusion to a patient in extremis due to a complete arterial transection at risk of fatal exsanguination. The type of vascular injury (contusion, laceration, and transection) is often related to the mechanism of trauma, as

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contusions are more commonly associated with hollow viscous or solid organ injuries due to significant blunt trauma, whereas complete transection of vessels is more commonly due to penetrating trauma.[3] Blunt trauma accounts for most mesenteric arterial injuries,[4,5] and is most frequently due to motor vehicle collisions, while penetrating trauma represents a less frequent cause with stab wounds encountered more frequently than gun shot wounds.[1] Regarding vessel involvement, injuries to the small bowel mesenteric vessels occur more frequently than to the large bowel[4] and can be divided into 2 broad injury types: those due to rapid deceleration with associated shearing forces and those caused by crush or external compression.[6] Shearing forces produced during deceleration tend to affect areas of fixation, making the ileocecal region and ligament of Treitz more susceptible to injury than other locations.[7] In patients with blunt trauma, it is not uncommon for both deceleration and compression injuries to be present simultaneously, as in the case of seat belt-related injuries seen in motor vehicle collisions.[5,6,8]

Because of the diverse presentation of patients with mesenteric arterial injuries, the patient's stability is the most important determinant in the workup and subsequent management of the injury, after initial trauma evaluation (ATLS). The advent of improved imaging techniques has also played a significant role in the advancement of mesenteric vessel injury identification and treatment, allowing for injuries, which may not have been detected in the past, to be found, but also allowing the use of endovascular interventions in certain circumstances.[7,9–11]

MATERIAL AND METHODS

This is a retrospective, descriptive study analyzing data from the 2012 National Trauma Data Bank (NTDB, from 2011 admission records from 744 facilities). Patients with injuries to the mesenteric arteries, as identified by International Classification of Disease 9 (ICD-9) codes 902.2–902.29 (Appendix 1) were included. Patients were excluded if gender or age data were not available. Patients who had a reported ISS of less than zero were also excluded. ISS scores used were as reported in the NTDB. Patient demographic information and clinical characteristics included age (<16, 16–20, 21–44, 45–64, and >65 years), gender, ISS (0–9, 10–15, 16–24, >25, and unknown), length of stay quartiles (LOS; 1–4, 5–8, 9–18, and 19–137 days), as well as disposition from the emergency department (ED) and final hospital disposition at the time of discharge.

Differences in injury mechanism, site of injury, and outcome based on patient characteristics (age group, gender, ISS group, race, and LOS quartiles) were analyzed using chi-square tests. Univariate analysis was used to determine likelihood of mortality based on patient demographics, injury type, and location; multivariable regression analysis was used to identify significant predictors of mortality. The results are reported as odds ratios (OR) with 95% confidence intervals (CI). Statistical significance was defined as $P < 0.05$. All analyses were performed using STATA® statistical software, version 12 (StataCorp, College Station, TX).

RESULTS

A total of 1,133 patients were included in this analysis. The 2012 NTDB includes a total of 832,800 patients, thus the overall incidence of mesenteric arterial injury was 0.14%. The majority of the patients included were men (78.2%), and the most common age group presenting was between 21 and 44 years (47.6%). The majority of injuries were due to blunt trauma (65%). Women were much more likely to present with blunt mechanism than men (84% vs. 60%, $P < 0.001$). In patients 16–20 years of age, there was no statistically significant difference between the proportion of penetrating and blunt injuries (48 vs. 49%), whereas in each of the other age groups, blunt trauma was the more common mechanism of injury (Table I). Higher ISS (>25) was found to be common in both penetrating and blunt injuries, however, 50% of patients with mesenteric vascular injuries due to blunt injuries had ISS >25, compared with 29% of those with penetrating injuries. Overall, 79% of blunt injuries had ISS>16, whereas 54% of penetrating injuries were associated with ISS>16 (Table II).

The most common arterial vessels injured were the splenic artery ($n = 252$, 22.2%), the celiac trunk ($n = 224$, 19.7%), the hepatic artery ($n = 175$, 15.4%), and the superior mesenteric artery (SMA) trunk ($n = 168$, 14.8%). For almost all arteries, blunt was the more common mechanism of injury with the exception of the gastric artery (65% vs. 33%, $P < 0.001$) (Table I).

Disposition from the ED varied significantly based on mechanism. The vast majority (85%) of patients presenting with penetrating trauma were taken directly from the ED to the operating room, whereas 44% of blunt injuries were taken directly for exploration. A significant number of blunt

Table I. Demographics of patients with mesenteric vascular injury

Demographic	Blunt	Penetrating	Other	Total	*P*-value
Gender					
Male	532 (60)	331 (37)	23 (3)	886	<0.001
Female	208 (84)	33 (13)	6 (2)	247	
Race					
White	539 (80)	114 (17)	18 (3)	671	<0.001
Black	70 (29)	167 (69)	6 (2)	243	
Other	131 (60)	83 (38)	5 (2)	219	
Age group					
<16	33 (80)	7 (17)	1 (2)	41	<0.001
16–20	61 (49)	60 (48)	4 (3)	125	
21–44	296 (55)	229 (42)	14 (3)	539	
45–64	236 (79)	57 (19)	6 (2)	299	
65+	114 (88)	11 (9)	4 (3)	129	
Vascular injury					
Celiac and mesenteric arteries, unspecified	156 (70)	63 (28)	5 (2)	224	<0.001
Gastric artery	45 (33)	89 (65)	3 (2)	137	
Hepatic artery	110 (63)	60 (34)	5 (3)	175	
Splenic artery	211 (84)	33 (13)	8 (3)	252	
Other branches of celiac axis	9 (75)	3 (25)	0	12	
Superior mesenteric artery trunk	102 (61)	60 (36)	6 (4)	168	
Primary branches of SMA	48 (67)	24 (33)	0	72	
Inferior mesenteric artery	20 (69)	9 (31)	0	29	
Celiac and mesenteric arteries, other	39 (61)	23 (36)	2 (3)	64	
Length of stay quartile					0.036
1 (1–4 days)	190 (26)	125 (34)	8 (28)	323	
2 (5–8 days)	177 (24)	89 (24)	9 (31)	275	
3 (9–18 days)	172 (23)	78 (21)	7 (24)	257	
4 (19–137 days)	201 (27)	72 (20)	5 (17)	278	
Total	740 (65)	364 (32)	29 (3)	1,133	

injuries were transferred to the intensive care unit (41%), compared with a small number of patients with a penetrating injury (5%). Overall, patients were unlikely to be admitted to the surgical floor (11% of blunt and 4% of penetrating). Patients were more likely to require nursing home or rehabilitation care after blunt injuries than penetrating (33% vs. 13%); patients with blunt injuries were also more likely to have required extended lengths of stay (Table I), whereas discharge to home was more common in the penetrating injury group (63% vs. 49%) (Table II). Only a small number of blunt (1%) and penetrating (3%) patients were declared deceased on ED arrival, however, 16% of blunt and 21% of penetrating injuries died during admission (Table II).

Patients with penetrating injuries were 1.43 times more likely to die from their injury than those suffering from blunt trauma (95% CI 1.04–1.98, $P < 0.05$). Patients with a higher ISS (16–25) were 5.39 times more likely to die than those with an ISS less than 16 (CI 1.89–15.4, $P = 0.002$), and with ISS 25+, a patient was 15.1 times more likely to die from their injuries (CI 5.5–41.7, $P < 0.001$) (Table III). Age was found to be associated with mortality, with patients 21–44 years and 65+ years more likely to die from their injuries than those in other age groups (OR 4.39, CI 1.04–18.5, and OR 5.41, CI 1.23–23.8, respectively, $P < 0.05$). There did not appear to be a difference in mortality between the sexes, but African American patients were 1.75 times more likely to die than Caucasian patients (CI 1.22–2.51, $P = 0.003$). Vessel-specific mortality demonstrated a significant increase in mortality in those with SMA trunk injuries (OR 3.03, CI 1.84–4.98, $P < 0.001$), as well as hepatic artery injuries (OR 2.03, CI 1.22–3.38, $P = 0.007$) when compared with unspecified vessels (Table III).

On multivariable regression analysis, predictors of mortality were determined based on patient demographics and injury characteristics (Table IV). The age group was predictive of mortality as patients 21–44 years as well as those 65 years or older were more likely to die from their injuries (OR 1.24, CI 1.03–1.49, $P < 0.05$) (Table V). Penetrating injury was also predictive (OR 1.77, CI 1.30–2.42,

Table II. Differences in disposition between patients with mesenteric vascular injury based on injury type

Disposition	Blunt	Penetrating	Other	Total	*P*-value
ER disposition					
Floor	81 (11)	16 (4)	4 (14)	101 (9)	<0.001
ICU	306 (41)	18 (5)	6 (21)	330 (29)	
OR	326 (44)	311 (85)	18 (62)	655 (58)	
Dead	6 (1)	12 (3)	1 (3)	19 (2)	
Other	21 (3)	7 (2)	0	28 (2)	
Hospital disposition					
Home	360 (49)	228 (63)	16 (55)	604 (53)	<0.001
Facility	245 (33)	46 (13)	5 (17)	296 (26)	
Dead	115 (16)	76 (21)	6 (21)	197 (17)	
Other	20 (3)	14 (4)	2 (7)	36 (3)	
ISS score					
0–9	78 (11)	73 (20)	8 (28)	159 (14)	<0.001
10–15	57 (8)	58 (16)	3 (10)	118 (10)	
16–24	213 (29)	90 (25)	8 (28)	311 (27)	
25+	368 (50)	106 (29)	10 (34)	484 (43)	
Unknown N/A	24 (3)	37 (10)	0	61 (5)	
Total	740	364	29	1,133	

$P < 0.001$) as was increased ISS (OR 2.17, CI 1.80–2.62, $P < 0.001$). Race was not found to be predictive of mortality although African Americans were more likely to present with penetrating injuries.

DISCUSSION

In this retrospective descriptive NTDB study, demographic data and outcomes of patients presenting with mesenteric arterial injuries due to blunt and penetrating trauma were analyzed. This represents the first large-scale review of national data regarding mesenteric vessel injuries published to date; therefore the data were gathered without expectation of specific characteristic or outcome differences on study initiation, although several findings stand out from the data collected.

Despite the relative frequency of abdominal trauma, whether due to blunt or penetrating injury, mesenteric vessel injury remains rare (0.1% of all traumatic injuries) but highly lethal (17% overall mortality). This analysis demonstrated significant differences in predominance of blunt over penetrating trauma, as reported previously in the literature,[12] except for patients between 16 and 20 years, at which point, the proportion of blunt injuries (49%) was nearly equal to penetrating injuries (48%). Penetrating injuries, although less common, carry a high risk of mortality (21%) and were more common in African-Americans than whites (69% vs. 17%). These findings, at least partially, are likely related to the incidence of gun-related deaths in 18–24 year olds[13]; however, further scrutinizing of the data to determine exact mechanism (gunshot wound versus stabbing) would be required to further explain this phenomenon. Patients who suffered penetrating injuries were 1.43 times more likely to die from their injuries, likely representing a catastrophic-localized injury. Patients with blunt injuries were less likely to die, but more likely to present with a higher ISS, demonstrating a trend toward significant blunt polytrauma. Considering the likelihood of polytrauma leading to multisystem injuries, it is not surprising that patients suffering from blunt injuries are more likely to require discharge to rehab or skilled nursing facilities, as demonstrated in Table II. Patients with blunt injury also remained hospitalized longer than those with penetrating injuries, ostensibly due to polytrauma-related conditions.

Many patients can be triaged and found not to require emergent surgery, nevertheless, a patient in extremis with abdominal injury warrants immediate exploration, however, with technological advances, CT has become commonplace and allows for a stable patient to undergo imaging before undergoing surgery, enabling calculated endovascular interventions.[7,11]

Although dogma states that penetrating abdominal wounds require immediate exploration, several patients who presented with penetrating mesenteric injuries were not taken to the operating suite from the ED. Four percent of these patients were transferred to the floor and 5% transferred to the intensive care unit. It is unclear if these patients were

Table III. Likelihood of death by parameters (univariate analysis)

Demographic	OR (95% CI)	*P*-value
Gender		
Male	Reference 1.0	
Female	0.96 (0.66−1.41)	0.857
Race		
White	Reference 1.0	
Black	1.75 (1.22−2.51)	0.003
Other	1.13 (0.75−1.71)	0.549
Age group		
<16	Reference 1.0	
16−20	3.94 (0.88−17.5)	0.073
21−44	4.39 (1.04−18.5)	0.044
45−64	3.64 (0.85−15.6)	0.082
65+	5.41 (1.23−23.8)	0.026
Injury type		
Blunt	Reference 1.0	
Penetrating	1.43 (1.04−1.98)	0.028
Other	1.42 (0.56−3.56)	0.457
ISS		
0−9	Reference 1.0	
10−15	2.08 (0.57−7.53)	0.266
16−24	5.39 (1.89−15.4)	0.002
25+	15.1 (5.5−41.7)	<0.001
Unknown/N/A	10.5 (3.3−33.7)	<0.001
Vascular injury		
Celiac and mesenteric arteries, unspecified	Reference 1.0	
Gastric artery	0.65 (0.33−1.30)	0.223
Hepatic artery	2.03 (1.22−3.38)	0.007
Splenic artery	0.66 (0.37−1.15)	0.144
Other branches of celiac axis	0.57 (0.07−4.53)	0.592
Superior mesenteric artery trunk	3.03 (1.84−4.98)	<0.001
Primary branches of SMA	1.00 (0.47−2.16)	0.992
Inferior mesenteric artery	2.37 (0.97−5.82)	0.060
Celiac and mesenteric arteries, other	1.44 (0.69−2.99)	0.333

later taken to the operating suite, if their clinical condition was closely associated with other injuries sustained or if their injuries were observed with serial abdominal examinations and repeat imaging if indicated.[11,14]

The increased risk of death in patients with SMA trunk injuries is consistent with previous data, given the previously reported survival rate of 50−55% in patients with penetrating SMA injuries requiring complex repair.[15−18] The size of the vessel injured is related to the mortality, as a patient is more likely to exsanguinate from a trunk than a small distal artery. Fullen's Anatomic Classification of Injuries to the SMA[19] created zones by which repair techniques are based, and the American Association for the Surgery of Trauma has classified injuries and correlated them to organ injury ratings.[20] Mortality rates have been linked to the Fullen zones, with 76%−100% mortality with zone I injury, (comprising the proximal SMA) and improved survival with distal injuries.[21,22]

Table IV. Likelihood of death by parameters (multivariate analysis)

Demographic	OR (95% CI)	*P* value
Race	1.00 (0.81−1.24)	0.971
Age group	1.24 (1.03−1.49)	0.022
Injury type	1.77 (1.30−2.42)	<0.001
ISS	2.17 (1.80−2.62)	<0.001

This study has several limitations, including the use of an administrative coding system to identify patients retrospectively. As it is a national database, using the NTDB is beneficial in that it represents the national practice rather than smaller geographic regions or single centers; however, this database requires that individual facilities record and report

Table V. Demographics of mesenteric vascular injuries by subtype

Demographic	Celiac and mesenteric arteries, unsp.	Gastric artery	Hepatic artery	Splenic artery	Other branches of celiac axis	SMA trunk	Primary branches of SMA	IMA	Celiac and mesenteric arteries, other	Total	*P*-value
Gender											0.110
Male	180 (20)	107 (12)	141 (16)	184 (21)	11 (1)	127 (14)	54 (6)	25 (3)	57 (6)	886	
Female	44 (18)	30 (12)	34 (14)	68 (28)	1 (0)	41 (17)	18 (7)	4 (2)	7 (3)	247	
Race											<0.001
White	133 (20)	71 (11)	87 (13)	176 (26)	8 (1)	93 (14)	46 (7)	18 (3)	39 (6)	671	
Black	38 (16)	43 (18)	43 (18)	31 (13)	2 (1)	48 (20)	12 (5)	8 (3)	18 (7)	243	
Other	53 (24)	23 (11)	45 (21)	45 (21)	2 (1)	27 (12)	14 (6)	3 (1)	7 (3)	219	
Age group											0.088
<16	9 (22)	3 (7)	10 (24)	12 (29)	0	2 (5)	2 (5)	1 (2)	2 (5)	41	
16−20	26 (21)	15 (12)	22 (18)	27 (22)	1 (1)	18 (14)	5 (4)	4 (3)	7 (6)	125	
21−44	120 (22)	70 (13)	95 (18)	97 (18)	8 (1)	71 (13)	40 (7)	11 (2)	27 (5)	539	
45−64	48 (16)	33 (11)	33 (11)	78 (26)	3 (1)	53 (18)	22 (7)	9 (3)	20 (7)	299	
65+	21 (16)	16 (12)	15 (11)	38 (29)	0	24 (19)	3 (2)	4 (3)	8 (6)	129	
Total	224 (20)	137 (12)	175 (15)	252 (22)	12 (1)	168 (15)	72 (6)	29 (3)	64 (6)	1,133	

data to it, leading to significant variability due to clerical and human error. One example of this is that the recording or reporting of vital signs (systolic blood pressure) was not consistent, requiring that patients included in the study could not be divided and analyzed in regard to their hemodynamic status on arrival as the number of instances where these data were not available prevented accurate analysis. Injury coding is also problematic as during exploratory or damage control laparotomies, it may not have been possible for the operator to identify specific vessels, leading to a significant number of ''other'' or ''unspecified'' entries when these arteries may have been named in nonemergent settings. Second-look laparotomies performed after initial damage-control procedures are also not included in these data, which would be helpful to fully describe injuries. Due to the high rate of concomitant injuries, particularly in patients suffering blunt trauma, with the current reporting system, it is not possible to determine if the eventual cause of death was related to a vascular injury or other injuries in these patients with polytrauma. Future research is needed to further analyze the relationship between location of vessel injury, mechanism, and outcome to better predict patient mortality. Vascular injury severity ranges from contusion to complete transection, and the lack of coding differentiation used likely oversimplifies the complex nature of these injuries.

CONCLUSION

Because of the risk of lethality associated with injuries to the mesenteric arterial vessels, it is imperative that these rare injuries be diagnosed and managed expeditiously. Penetrating mechanism, ISS, and age are associated with increased mortality, but morbidity and mortality remain high for all demographic groups and injury patterns.

SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.avsg.2020.08.101.

REFERENCES

1. Watts DD, Fakhry SM, EAST Multi-Institutional Hollow Viscus Injury Research Group. Incidence of hollow viscus injury in blunt trauma: an analysis of 275,557 trauma admissions from the EAST Multi-institutional Trial. J Trauma 2003;54:289−94.
2. Killee KL, Shanmuganathan K, Poletti PA, et al. Helical computed tomography for bowel and mesenteric injuries. J Trauma 2001;51:26−36.

3. Wilson A, Knight J. Mesenteric arterial trauma. In: Yeo CJ ed. Shackelford's Surgery of the Alimentary Tract. Philadelphia: Elsevier, 2012. pp 961–5.
4. Nolan BW, Gabram SG, Schwartz RJ, et al. Mesenteric injury from blunt abdominal trauma. Am Surg 1995;61:501–6.
5. Xeropotamos NS, Nousias VE, Ioannou HV, et al. Mesenteric injury after blunt abdominal trauma. Eur J Surg 2001;167:106–9.
6. Hughes TM, Elton C. The pathophysiology and management of bowel and mesenteric injuries due to blunt trauma. Injury 2002;33:295–302.
7. Yu J, Fulcher AS, Turner MA, et al. Blunt bowel and mesenteric Injury: MDCT diagnosis. Abdom Imaging 2011;36:50–61.
8. Rutledge RMD, Thomason MMD, Oller DMD, et al. The spectrum of abdominal injuries associated with the use of seat belts. J Trauma 1991;31:820–6.
9. Woo K, Margulies DR, Gaon MD, et al. Intracorporeal laparoscopic management of mesenteric avulsion in a blunt trauma patient. J Trauma 2009;67:E104–7.
10. Asayama Y, Matsumoto S, Isoda T, et al. A case of traumatic mesenteric bleeding controlled by only transcatheter arterial embolization. Cardiovasc Intervent Radiol 2005;28:256–8.
11. Klein EN, Kirton OC. Mesenteric arterial trauma. In: Yeo CJ ed. Shackelford's Surgery of the Alimentary Tract. Philadelphia: Elsevier, 2019. pp 1056–60.
12. Konstantinidis A, Inaba K, Dubose J, et al. Vascular trauma in geriatric patients: a national trauma databank review. J Trauma Acute Care Surg 2011;71:909–16.
13. Gun homicide rate down 49% since 1993 peak; Public Unaware: Chapter 2. Firearm Deaths. Pew Research Center, Washington, DC. Available at: http://www.pewsocialtrends.org/2013/05/07/chapter-2-firearm-deaths/. Accessed May 7, 2013.
14. Corzo C, Murdock AD, Alarcon L, et al. Mesenteric hematoma: is there a role for selective management? Am Surg 2016;82:314–8.
15. Fakhry SM, Brownstein M, Watts DD, et al. Relatively short diagnostic delays (<8 hours) produce morbidity and mortality in blunt small bowel injury: an analysis of time to operative intervention in 198 patients from a multicenter experience. J Trauma 2000;48:408–14.
16. Fakhry SM, Watts DD, Luchette FA, et al. Current diagnostic approaches lack sensitivity in the diagnosis of perforated blunt small bowel injury: analysis from 275,557 trauma admissions from the EAST multi-institutional HVI trial. J Trauma 2003;54:295–306.
17. Nishijima DK, Simel DL, Wisner DH, et al. Does this adult patient have a blunt intra-abdominal injury? JAMA 2012;307:1517–27.
18. Woodhall JP, Ochsner A. The management of perforating injuries of the colon and rectum in civilian practice. Surgery 1951;29:305–20.
19. Fullen WD, Hunt J, Altemeier WA. The clinical spectrum of penetrating injury to the superior mesenteric arterial circulation. J Trauma 1972;12:656–64.
20. Moore EE, Cogbill TH, Malangoni M, et al. Scaling system for organ specific injuries. Available at: http://www.aast.org/Library/TraumaTools/InjuryScoringScales.aspx. Accessed November 12, 2018.
21. Asensio JA, Britt JD, Borzotta A, et al. Multi-institutional experience with the management of superior mesenteric artery injuries. J Am Coll Surg 2001;193:354–65.
22. Asensio JA, Berne JD, Chahwan S, et al. Traumatic injury to the superior mesenteric artery. Am J Surg 1999;178:235–9.