# The American Association for the Surgery of Trauma Severity Grade is valid and generalizable in adhesive small bowel obstruction

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**BACKGROUND:** The American Association for the Surgery of Trauma (AAST) anatomic severity grading system for adhesive small bowel obstruction (ASBO) was validated at a single institution. We aimed to externally validate the AAST ASBO grading system using the Eastern Association for the Surgery of Trauma multi-institutional small bowel obstruction prospective observational study.

**METHODS:** Adults (age ≥ 18) with (ASBO) were included. Baseline demographics, physiologic parameters (heart rate, blood pressure, respiratory rate), laboratory tests (lactate, hemoglobin, creatinine, leukocytosis), imaging findings, operative details, length of stay, and Clavien-Dindo complications were collected. The AAST ASBO grades were assigned by two independent reviewers based on imaging findings. Kappa statistic, univariate, and multivariable analyses were performed.

**RESULTS:** There were 635 patients with a mean (±SD) age of 61 ± 17.8 years, 51% female, and mean body mass index was 27.5 ± 8.1. The AAST ASBO grades were: grade I (n = 386, 60.5%), grade II (n = 135, 21.2%), grade III (n = 59, 9.2%), grade IV (n = 55, 8.6%). Initial management included: nonoperative (n = 385; 61%), laparotomy (n = 200, 31.3%), laparoscopy (n = 13, 2.0%), and laparoscopy converted to laparotomy (n = 37, 5.8%). An increased median [IQR] AAST ASBO grade was associated with need for conversion to an open procedure (2 [1–3] vs. 3 [2–4], $p = 0.008$), small bowel resection (2 [2–2] vs. 3 [2–4], $p < 0.0001$), postoperative temporary abdominal closure (2 [2–3] vs. 3 [3–4], $p < 0.0001$), and stoma creation (2 [2–3] vs. 3 [2–4], $p < 0.0001$). Increasing AAST grade was associated with increased anatomic severity noted on imaging findings, longer duration of stay, need for intensive care, increased rate of complication, and higher Clavien-Dindo complication grade.

**CONCLUSION:** The AAST ASBO severity grading system has predictive validity for important clinical outcomes and allows for standardization across institutions, providers, and future research focused on optimizing preoperative diagnosis and management algorithms. (*J Trauma Acute Care Surg.* 2018;84: 372–378. 

**LEVEL OF EVIDENCE:** Prognostic, level III.

**KEY WORDS:** SBO; AAST; grade; severity; emergency general surgery.

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Adhesive small bowel obstruction (ASBO) represents a significant surgical challenge and accounts for a large proportion of postoperative morbidity.[1] Surgical outcomes for ASBO are influenced by the type and extent of previous surgical operations, patient age, and comorbidity status, as well as physiologic changes.[2–5] Central to current ASBO therapy is predicting failure of nonoperative management (NOM) and subsequent need for operative intervention which may be difficult.[6] Early diagnosis is important as delays may result in severe complications; however, operating too soon may result in unnecessary adhesiolysis that was destined to resolve. Asssessing ASBO severity is complex because various preoperative physiologic and imaging variables discriminate patient management with different accuracy.[7–12] Since there is a lack of universally accepted ASBO severity definitions, methods to equitably compare patient cohorts are complicated.[13]

The American Association for the Surgery of Trauma (AAST) Emergency General Surgery (EGS) grading scale is designed assign disease severity.[14] Consideration of patients' initial degree of ASBO anatomic insult and associated severity has been previously evaluated in a single institutional review using this EGS grading system.[13,15,16] The AAST EGS ASBO grade accurately describes EGS disease severity using clinical, imaging,

operative, and pathologic criteria, and it correlates with patient physiology, management, and outcomes for several diseases including ASBO.[14,15,17–20]

In the present study, we aimed to analyze the generalizability of the AAST EGS grade for ASBO using a multi-institutional prospectively collected observational data set from an Eastern Association for the Surgery of Trauma (EAST)-sponsored multicenter study. We hypothesized that the AAST ASBO grade would be sufficiently valid to describe patient physiology, management, and postoperative outcomes. Correlation of the AAST ASBO grade with these outcomes would prove its construct and consequential validity and provide additional evidence for its generalizability.

## METHODS

This was a secondary analysis (planned *a priori*) of the EAST multi-institutional propsective, observational study for ASBO. Institutional review board approval was obtained at each study site. Data included in this study were obtained from all participating institutions.

### ASBO Inclusion/Exclusion Criteria

The diagnosis of ASBO was based on radiographic imaging demonstrating dilated loops of small bowel with a transition point in the clinical setting of nausea, vomiting, abdominal pain with distension. To ensure that patients with ASBO only were included, the following exclusion criteria were applied: presence of external/internal hernia, a history of abdominopelvic malignancy, and a laparoscopic or open abdominal exploration within the preceeding six weeks.

### Determination of the AAST ASBO Grade

The AAST ASBO grades were generated from radiographic and operative findings provided in the EAST database. All patients with cross-sectioning imaging had an imaging based AAST grade generated. The AAST grades were assigned also using the AAST operative criteria as previously defined (Table 1).[14] The AAST grades were generated by two separate reviewers (N.N.H. and H.S), and a third reviewer (M.C.H) adjudicated any grade discrepancies to create a final AAST grade. Analysis of outcomes were based on the imaging-based AAST grade. Small bowel feces sign was defined as luminal gaseous bubbles and debris within the obstruced segment of bowel. Mesenteric edema was defined as any hazy appearing fluid that attenuated in the mesentery of the affected segment of bowel. Obstipation was defined as the apparent lack of anal exsufflation or bowel movement for 24 or more hours.

### Patient Characteristics

Patient characteristics collected included age, sex, body mass index (BMI), hospital study site, previous surgical operations, prior ASBO admission, previous laparotomy for ASBO, previous history of open abdomen, or temporary abdominal closure. Physiologic characteristics collected at admission included systolic blood pressure (SBP), heart rate (beats per minute), respiratory rate, leukocytes (white blood cell [WBC]/uL), and overall degree of organ dysfunction (normal, systemic inflammatory response syndrome, sepsis, multiple organ dysfunction) as defined by sepsis criteria[21] and days of obstipation.

### Operative and Nonoperative Therapy

Management strategies were recorded and included operative or NOM. For patients managed with surgery, operative duration (minutes), time from ED arrival to operation (minutes), operation type (laparoscopy, laparotomy, laparascopy converted to laparotomy), need for small bowel resection, need for ostomy formation, need for cecostomy tube, and extent of peritoneal contamination were collected.

### Postoperative Outcomes and Predictors of Disease Severity

After operative or NOM therapy, the primary outcome was development of postoperative complications, need for intensive care unit (ICU) care, and overall duration of hospital stay. The complication list was defined *a priori* and includes acute kidney injury (AKI, defined as an increase of baseline creatinine threefold),[22] pneumonia, surgical site infection, surgical site infection (superficial, deep, and organ space), anastomotic leak, pneumonitis secondary to oral contrast administration. The complications were classified using the Clavien-Dindo complication system.[23]

### Statistical Analysis

Continuous variables were presented as means with SD and compared using the unpaired two-sample test while nonnormally distributed data were presented as median (interquartile

**TABLE 1.** AAST Grading Criteria for SBO

| Grade | Description | Radiographic Criteria | Operative Criteria |
|---|---|---|---|
| I | Partial SBO | Minimal intestinal distension | Minimal intestinal distension with no evidence of obstruction |
| II | Complete SBO; bowel viable and not compromised | Intestinal distension with transition point without bowel compromise | Intestinal distension with transition point; no evidence of bowel compromise |
| III | Complete SBO with compromised but viable bowel | Intestinal distension with transition point, no distal contrast flow, evidence of complete obstruction or impending bowel compromise | Intestinal distention with impending bowel compromise |
| IV | Complete SBO with nonviable bowel or perforation with localized spillage | Evidence of localized perforation or free air; bowel distension with free air or free fluid | Intestinal distension with localized perforation or free fluid |
| V | SB perforation with diffuse peritoneal contamination | Bowel perforation with free air and free fluid | Intestinal distension with perforation, free fluid and evidence of diffuse peritonitis |

SB, small bowel.

**TABLE 2.** Baseline Patient Characteristics

| | I | II | III | IV | |
|---|---|---|---|---|---|
| | N = 386 | N = 135 | N = 59 | N = 55 | *p* |
| Age* | 62 [49–75] | 63 [53–76] | 61 [47–73] | 72 [58–84] | 0.02 |
| % Female† | 47.6 | 54 | 57.6 | 52.1 | 0.6 |
| Heart rate** | 84.3 (±16) | 86.1 (±16.7) | 83.4 (±18.8) | 87.9 (±17.9) | 0.3 |
| SBP** | 131 [119–146] | 137 [122–150] | 141 [125–154] | 140 [126–160] | 0.04 |
| Lactate** | 1.6 (±1.5) | 1.7 (±1.0) | 1.5 (±0.9) | 1.5 (±0.7) | 0.5 |
| WBC** | 9.6 [7.2–12.5] | 10.1 [7.3–13.8] | 10.2 [6.7–12.9] | 11.4 [7.8–15.1] | 0.1 |
| Peritonitis† | 2.6 | 10.4 | 12.1 | 14.8 | 0.001 |
| Days of Obstipation* | 1 [0–2] | 1 [0–2] | 1 [0–4] | 1 [0–2] | 0.1 |
| Sepsis† | 1.4 | 6.9 | 6.66 | 14.5 | 0.001 |

*Values reported as median [IQR].
**Values reported as mean (±SD).
†Percentages as appropriate. Spearman's ρ was used for continuous variables and Cochran Armitage test for trend for categorical variables.

range [IQR]). We examined differences and associations of the AAST grade with patient characteristics and outcomes using Spearman's ρ (continous variables) or the Cochran Armitage test for trend (categorical variables). Categorical variables were presented as percentages and analyzed with the Fisher's exact test when appropriate. The inter-rater reliability was assessed using a measurement of agreement via the kappa statistic with substantial agreement defined as greater than 0.70. Inter-rater reliability was assessed using the kappa coefficent with 95% confidence intervals (CI). Grade I was used as a reference for comparison (II–V). Since AAST grade V contained few samples (n < 10), this was combined with AAST grade IV for all analyses. Statistical significance was defined as a *p* value less than 0.05. For incomplete data (>10%), analyses to determine the association of anatomic injury severity and outcomes were not performed. Rates of missing data included CT imaging (small bowel feces sign, 9%; free fluid, 4%; mesenteric edema, 7%; closed loop obstruction, 4%; transition point, 5%); for the remaining physiologic and laboratory variables, there were less than 7% missing data. Based on this, no patients were excluded from the final analysis.

To account for the clustering effect of patients within different hospitals, we used generalized estimating equations using variance estimates with 95% CIs. We also considered several potential confounders and included the following covariates admitting service type (surgical versus nonsurgical), age, sex, BMI, and patient physiologic status. Logistic regression with odds ratio (OR) 95% CI was performed, using the generalized estimating equation to control for clustering by each study center, to model development of postoperative complication. Model performance and diagnostics was performed using area under the reciever operating characteristic (with 95% CI), residual plots, and the Hosmer-Lemeshow $\chi^2$ test. All analyses were conducted using SATA version 12.1 (STATA Corp LP).

## RESULTS

### Overall Patient Characteristics

There were 635 patients with a mean (±SD) age of 61 ± 17.8 years. Fifty-one percent were women, and the cohort had a mean BMI (±SD) of 27.5 ± 8.1. A total of 531 (84%) patients had a previous abdominal operation, 107 (20%) of whom underwent laparotomy for previous ASBO. Two hundred sixteen (34%) patients were previously admitted for ASBO. The frequency of AAST grades for the overall cohort included grade I (n = 386, 60.5%), grade II (n = 135, 21.2%), grade III (n = 59, 9.2%), grade IV (n = 55, 8.6%). The degree of agreement between reviewers was 0.74 (95% CI, 0.70–0.77) which indicates substantial agreement. The volume of patients at each site included Mayo Clinic (n = 144), Marshfield Clinic (n = 83), Loma Linda (n = 69), Cooper Health System (n = 60), University of Southern California (n = 54), Massachusetts General Hospital (n = 45), John Peter Smith (n = 42), Kern Medical Center (n = 36), Inova Fairfax Hospital (n = 31), Walter Reed National Military Medical Center (n = 21), Geisinger Medical Center (n = 14), Greenville Memorial Hospital (n = 13), UC Health Northern Colorado

**TABLE 3.** AAST Grade Compared With Preoperative Cross-Sectional Imaging Findings and Postoperative Outcomes

| | AAST SBO Grade | | | | |
|---|---|---|---|---|---|
| | I | II | III | IV | |
| | N = 386 | N = 135 | N = 59 | N = 55 | *p* |
| SB feces sign* | 29% | 26% | 20% | 8% | <0.001 |
| Closed loop obstruction* | 2% | 13% | 13% | 19.1% | <0.001 |
| Free fluid* | 31% | 43% | 48% | 50% | 0.1 |
| Mesenteric edema | 23% | 27% | 40% | 24.4% | 0.3 |
| Transition point | 70% | 79% | 60% | 40% | 0.04 |
| Duration of stay** | 3 [2–6] | 8 [6–15] | 10 [6–17] | 14 [9–22] | <0.001 |
| Clavien-Dindo grade** | 0 [0–0] | 0 [0–2] | 0 [0–3] | 2 [0–4] | <0.001 |
| Complication* | 25% | 37% | 42% | 62% | <0.001 |
| ICU admission* | 4% | 20% | 32% | 69% | <0.001 |
| AKI* | 5.4% | 7.8% | 12.1% | 22.2% | 0.003 |
| Pneumonia* | 2.6 | 6.3 | 5.1 | 7.4 | 0.02 |

*Percentages as appropriate Spearman's ρ was used for continuous variables and Cochran Armitage test for trend for categorical variables.
**Values reported as median [IQR].
†Values reported as means (±SD).

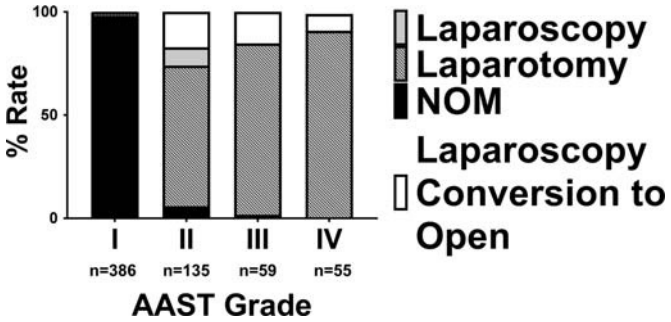


**Figure 1.** AAST grade and operative approach.

(n = 8), East Carolina (n = 8), and San Antonio Military Medical Center (n = 7).

Baseline patient characteristics are presented in Table 2, demonstrating that there was a significant variability between grades for SBP increasing through AAST ASBO grade V ($p$ = 0.001). Increasing anatomic severity was not significantly associated with, lactate, or WBC, (Table 2). However, the increasing degree of organ dysfunction,[21] including sepsis and peritonitis, correlated with increasing AAST grade I–IV ($p$ = 0.001). Specifically, patients with AAST grade V disease had diminished signs of peritonitis and clinically overt sepsis compared to grade IV. With respect to duration of prehospital obstipation, there was no association with increasing AAST ASBO grade. The percentage of patients who presented with peritonitis on physical examination displayed incrementally more severe disease at operation ($p$ = 0.001).

The AAST ASBO grade was associated with increased anatomic severity based on imaging (Table 3). The presence of a small bowel feces sign was associated with less severe AAST ASBO grades ($p$ = 0.001). For increasing AAST grade, the presence of a closed loop obstruction was more likely ($p$ = 0.001). The presence of a clear transition point was more frequently evident in less severe disease ($p$ = 0.04). The presence of intraperitoneal fluid and mesenteric edema was not associated with more severe AAST grades ($p$ = 0.1 and $p$ = 0.3, respectively). Missing data points for cross sectional imaging included colonic gas (n = 87), small bowel feces sign (n = 52), free intraperitoneal fluid (n = 22), mesenteric edema (n = 61), closed loop obstruction (n = 27), and transition point (n = 31).

## Operative or NOM Therapy and AAST Grade

Initial management included nonoperative (n = 388; 61%), laparotomy (n = 200, 31.3%), laparoscopy (n = 13, 2.0%), and laparoscopy converted to laparotomy (n = 37, 5.8%). Initial management approach corresponding to AAST grade is demonstrated in Figure 1. An increased median [IQR] AAST grade was associated with need for conversion to an open procedure (2 [1–3] vs. 3 [2–4], $p$ = 0.008), small bowel resection (2 [2–2] vs. 3 [2–4], $p < 0.001$), postoperative temporary abdominal closure (2 [2–3] vs. 3 [3–4], $p < 0.001$), and stoma creation (2 [2–3] vs. 3 [2–4], $p < 0.001$). Figure 2 highlights the increasing incidence of stoma creation, small bowel resection, anastomosis at index procedure, and rates of laparoscopy converted to laparotomy by increasing AAST grade.

## Postoperative Outcomes and AAST Grade

Postoperative outcomes were associated with the AAST ASBO grade (I–V) as outlined in Table 3. Figure 3 demonstrates the association of increasing AAST ASBO grade with increased complication severity as defined by Clavien and Dindo as well as overall duration of stay. The overall rate of mortality was 1.3% (n = 8) with a complication rate of 32% (n = 205). The adjusted OR of developing any postoperative complication was associated with increasing AAST ASBO grade OR (95% CI): AAST grade I (reference), AAST grade II OR, 1.78 (95% CI, 1.1–2.8), AAST grade III OR, 2.8 (95% CI, 1.4–5.6), AAST grade IV OR, 4.7 (95% CI 2.3–9.9) ($p < 0.0001$). The following covariates did not demonstrate statistical significance patients developing a postoperative complication: admitting service type (surgical versus nonsurgical), age, sex, BMI, patient physiologic criteria, and intrahospital variation (all $p > 0.05$). The model demonstated moderate discrimination of postoperative complication with an area under the reciever operating characteristic (0.76; 95% CI, 0.72–0.78) and calibration (Hosmer-Lemeshow $\chi^2$ test, $p$ = 0.003).

# DISCUSSION

Several methods to evaluate disease severity exist; however, only the AAST EGS grade takes into account anatomic injury. This analysis of a multi-institutional prospectively collected observational data set demonstrates that the AAST

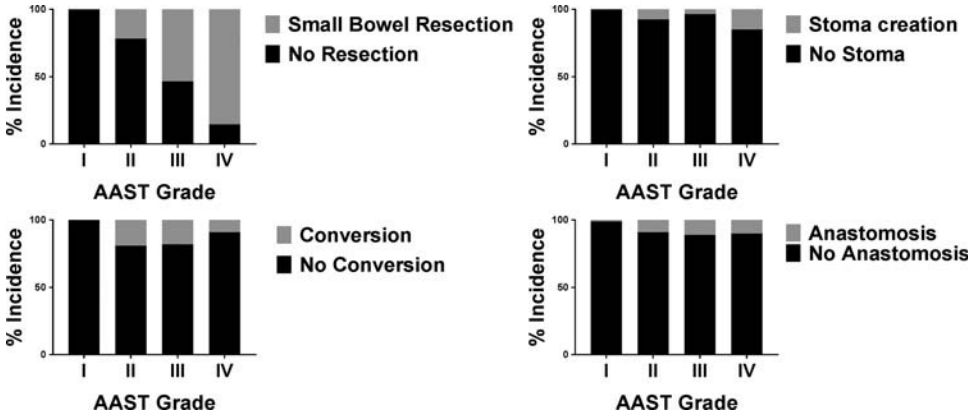


**Figure 2.** AAST grade and operative maneuvers.

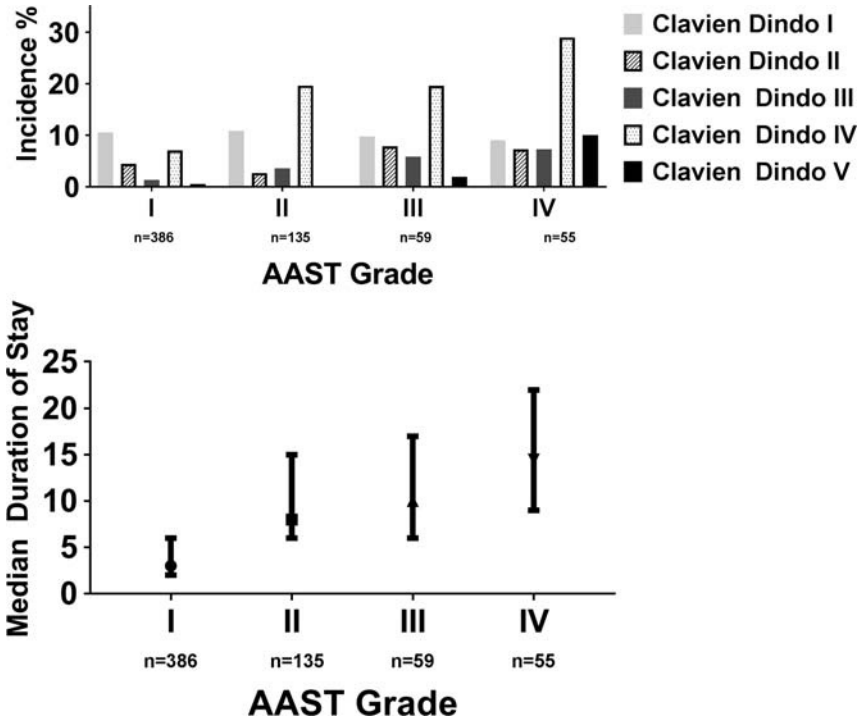


**Figure 3.** AAST grade is associated with complication severity and duration of stay incrementally.

ASBO grade corresponds with the degree of organ dysfunction, management strategy, and postoperative outcomes. Our interpretation suggests that the AAST ASBO grading scale demonstrates broad generalizability as a method to assess disease severity for patients with ASBO.

Previously, there had been no method to assess ASBO anatomic injury severity in a standardized manner. Predicting the type of intervention a patient will need is difficult.[24] Anatomic injury does not necessarily drive management given that this cohort focused heavily on operative versus nonoperative approaches. To address this, several clinical prediction models have been developed, each incorporating various amounts of patient information to predict the need for operation.[7–12] These models do not routinely incorporate specific imaging-based anatomic injuries and therefore are limited. The type of surgical intervention required (resection, stoma, anastomosis) in ASBO is likely based on the degree of anatomic injury. Baghdadi et al.[15] demonstrated initially that the AAST description of anatomic injury could also be incorporated with physiologic and comorbid parameters in order to predict mortality. Although the AAST ASBO grade alone is not a clinical prediction model to determine operative need, incremental changes in anatomic injury influence disease severity. Further, surgeons also utilize preoperative presenting physiology and several laboratory parameters to estimate disease severity. Several studies have evaluated the presence of deranged physiology or laboratory parameters in the setting of severe small-bowel obstruction (SBO) and demonstrate worse outcomes.[25,26] Patient comorbidity status also impacts patient outcomes in EGS.[27,28] Integration of the AAST grade with patient comorbidity and physiologic status, in future analyses of aggregate databases, may demonstrate an improved method to predict operative intervention.

In our study, patients that received an operation demonstrated increased AAST grades (III–V) compared with those that received NOM (I–II). The AAST ASBO grade was able to accurately correspond with the intervention for grade I. For grades II–V, the diminished utilization of laparoscopy coupled with laparoscopy conversion to laparotomy suggests that increasing anatomic injury influences operative approach. This suggests that patients with increasing disease severity may more frequently require adhesiolysis. In patients undergoing operative intervention, advanced anatomic injury was associated with the need for additional manipulations beyond adhesiolysis, such as small bowel resection, anastomosis, or stoma creation. As patients with increasing disease severity required more invasive maneuvers, these appeared to correlate with the AAST grade. The utilization of laparoscopy diminished with increasing AAST ASBO grade, suggesting increasing operative difficulty or that advancing anatomic injury portends acute physiology making laparoscopic approaches difficult. Currently, our analysis cannot recommend which patients should undergo laparoscopic versus open adhesiolysis; however, future research incorporating the AAST ASBO grade to predictive models may help strengthen algorithms to improve surgical decision making.

Schraufnagel et al.[29] demonstrated that delay in surgery for ASBO was associated with increased hospital duration of stay and mortality. In our cohort, increasing AAST ASBO grade was associated with increasing frequency of complications and increasing complication severity as described by Clavien and Dindo. Moreover, increasing AAST grade was associated with increased frequency of need for ICU level care, development of acute kidney injury, postoperative pneumonia, and increased overall duration of hospital stay. Similarly, Baghdadi et al.[15] previously reported that the AAST ASBO grading system can predict extended duration of stay and complications. This

multi-institutional data set provides further evidence that AAST ASBO grade can accurately stratify disease severity and its associations with important clinical outcomes.

This study has several limitations. Our study was not able to validate the pathologic criteria which were added to the AAST EGS grading system because these criteria were not present at study initiation. Assignment of disease severity may have led to bias; however, our kappa statistic indicated substantial agreement. Not all imaging reports provided granular detail in this study and for incomplete data (>10%) analyses to determine the association of anatomic injury severity, and outcomes were not performed. This did not affect our AAST imaging grade since there was no missing data that were >10% for each radiologic finding. This analysis represents a review of previously published work and that the intended nature of the original data set was not designed for broad scale validation of the AAST EGS grade. Additionally, despite the multi-institutional setting, there were few patients with AAST ASBO Grade V disease limiting the ability to perform statistical analyses. Despite these limitations, application of the AAST grade for ASBO provided meaningful analyses that described several clinical outcomes. Moreover, incorporation of AAST ASBO grade may provide an additional method for comparison of patient cohorts.

Aggregate databases, like the American College of Surgeons National Surgical Quality Improvement Program, provide powerful risk assessment tools to plan, educate, and improve outcomes.[30] Optimizing preoperative algorithms to better triage and manage patients with ASBO is needed in order for improved risk-assessment and stratification of disease severity. Surgical decision making incorporates abundant clinically relevant patient data and each is of different significance and patient dependent. The addition of the AAST ASBO grade can increase the ability to accurately compare outcomes between operators, hospitals, and healthcare systems.

## CONCLUSION

The AAST grading scale for ASBO is associated incrementally with patient outcomes, specifically development of complication and length of stay. The equitable comparison of patients with variable disease is now possible and research should target improving current clinical prediction models to enhance current management algorithms and better estimate patient risks. Future research for ASBO and other EGS diseases should incorporate standardized anatomic disease definitions. The association of patient anatomy, physiology, and comorbidities clearly constitute an epidemiological triad for this disease and provide adequate measurement to stratify EGS disease severity is now validated.

### AUTHORSHIP

M.H., N.H., D.C., D.Y., K.I., T.D., A.P., C.R., J.D., V.S., and M.Z. contributed to the design, conception, analysis, interpretation, drafting and final approval of the work. The remaining authors (A.C., D.T., J.M.Y., S.W., R.S., J.W., K.A.W., J.C., E.A.T., J.C.G.) contributed to analysis, interpreation, drafting, and final approval of the work.

### DISCLOSURE

The authors have no conflicts of interest or funding related to this work to declare.

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