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Obesity does not confer visceral protection in clinically relevant penetrating abdominal trauma: A retrospective cohort study

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Abstract

The obesity paradox has been described in blunt trauma, where adiposity may attenuate energy transfer and reduce injury severity. Whether this applies to clinically relevant penetrating abdominal trauma remains unclear. To evaluate whether obesity, defined by body mass index, is associated with reduced intra-abdominal organ injury in adults with clinically relevant penetrating abdominal trauma. This retrospective cohort study included adults presenting with clinically relevant penetrating abdominal trauma at a tertiary trauma centre between January 1, 2020, and December 31, 2025. Of 710 screened patients, 25 with isolated superficial injuries, 35 with inaccessible records, and 100 with missing body mass index (BMI) data were excluded; 550 patients were analyzed. The primary outcome was intra-abdominal organ injury. Multivariate penalized logistic regression assessed the association between obesity and injury occurrence, adjusting for injury mechanism, hemodynamic status, and other clinically available covariates. Mechanism-stratified analyses and ROC analysis of BMI were also performed. Among 550 patients, 339 (61.6%) sustained intra-abdominal organ injury. Obesity was not independently associated with organ injury after adjustment (adjusted OR, 1.33; 95% CI, 0.75 – 2.34). In mechanism-stratified analyses, obesity was not associated with organ injury in stab wounds, whereas the firearm subgroup showed wide confidence intervals. No BMI – mechanism interaction was observed. BMI showed poor discrimination for any organ injury (AUC ≈0.51), with similarly limited performance for solid and hollow viscus injuries. In patients with clinically relevant penetrating abdominal trauma, obesity did not confer visceral protection and BMI had no meaningful predictive value for injury risk. Because isolated superficial injuries were excluded, these findings do not exclude a possible effect of adiposity on fascial penetration. They suggest that, once clinically relevant penetrating trauma is present, the obesity paradox described in blunt trauma does not extend to penetrating mechanisms and should not influence clinical risk assessment.

Keywords: Penetrating abdominal trauma, obesity, body mass index, organ injury, trauma surgery, obesity paradox

Introduction

Obesity is increasingly prevalent globally and among trauma patients. Although commonly associated with cardiovascular and metabolic diseases, obesity has become a focus of trauma research because of the so-called "obesity paradox." This phenomenon refers to the observation that overweight or moderately obese patients may experience similar or even improved outcomes compared to normal-weight individuals, particularly in blunt trauma. Both mechanical and physiological mechanisms have been proposed to explain this effect. Recent trauma studies have demonstrated heterogeneous effects of obesity on injury severity and clinical outcomes, suggesting that the influence of body habitus may vary according to injury mechanism, anatomical region, and physiological status rather than representing a uniform protective phenomenon [1].

In blunt abdominal trauma, increased subcutaneous fat may decrease the transfer of kinetic energy to intra-abdominal organs. This reduction can lower injury severity. Large registry studies have reported fewer abdominal organ injuries with increasing body mass index (BMI), supporting a mechanical cushioning effect [2]. Contemporary clinical cohorts suggest obesity influences injury patterns in blunt trauma, rather than just increasing overall injury burden [3]. Earlier biomechanical investigations of motor vehicle collisions have also found that greater subcutaneous fat thickness may be associated with less severe abdominal injuries. This finding supports the idea of energy dissipation through soft tissue [4].

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However, this protective effect is not always observed, even in cases of blunt trauma. Studies on bowel and mesenteric injuries have not shown that obesity is protective. This suggests that extra body fat does not protect all organs inside the abdomen. The mixed results indicate that any protection is likely to depend on the type and force of the injury, and not on a general effect. Large trauma registry studies have demonstrated complex and sometimes adverse associations between obesity and trauma outcomes, suggesting that body mass index alone may not reliably predict injury severity or clinical course [5].

Penetrating abdominal trauma works differently. Instead of spreading force through the tissues, these injuries cause direct damage along a set path. In stab wounds, the tissue is sharply cut with little energy spreading to the sides. Gunshot injuries depend on the speed, size, and movement of the bullet, not just the thickness of body fat. For body fat to protect organs in these cases, it would need to change the depth or path of the injury before it reaches important organs. It is not clear if this happens in a way that matters for patients.

Contemporary trauma outcome studies have highlighted the importance of mechanism-specific risk assessment models, particularly in penetrating trauma where injury trajectory and energy transfer characteristics are the primary determinants of visceral injury [6].

Given the rising prevalence of obesity and the ongoing incidence of penetrating trauma, it is important to determine whether obesity provides protection to the internal organs in such injuries. This study aimed to evaluate whether BMI alone can predict organ injury in patients with clinically relevant penetrating abdominal trauma.

Material and Methods

Study Design and Setting

This study was conducted at the emergency trauma referral center of a tertiary academic hospital. The study period extended from January 1, 2020, to December 31, 2025, and all eligible adult patients presenting with penetrating abdominal trauma during this period were screened. This study was approved by the Non-Interventional Clinical Research Ethics Committee of Mersin City Training and Research Hospital (Approval No: 2026/131; Date: 25 February 2026).

Study Population

All patients aged ≥ 18 years with penetrating abdominal trauma were screened for eligibility. Penetrating abdominal trauma was operationally defined as a penetrating injury involving the anterior abdominal wall, flank, back, or thoracoabdominal region with suspected or confirmed fascial violation or a wound trajectory requiring radiological evaluation, operative exploration, or structured clinical observation. Penetrating mechanisms included stab wounds and firearm-related injuries. Patients were included if intra-abdominal injury status could be determined through radiological evaluation, operative exploration, and/or structured clinical observation. Patients managed non-operatively with negative imaging and no subsequent clinical evidence of intra-abdominal injury during observation were classified as having no intra-abdominal organ injury.

Exclusion criteria were:

1. Isolated superficial injuries not breaching the abdominal fascia,
2. Incomplete medical documentation preventing outcome ascertainment,
3. Missing anthropometric data precluded BMI calculation.

During the study period, 710 patients were initially screened. Of these, 25 were excluded because of isolated superficial injuries not breaching the abdominal fascia, 35 because their medical records could not be accessed, and 100 because of missing BMI data. The final analysis included 550 patients.

Because isolated superficial injuries were excluded, the present study does not directly evaluate whether obesity prevents fascial penetration. Instead, the analysis specifically examines whether obesity is associated with a reduced risk of intra-abdominal organ injury among patients with clinically relevant penetrating abdominal trauma in whom intra-abdominal injury status could be assessed.

Consecutive inclusion was applied to minimize selection bias. Patient selection and cohort allocation are illustrated in Figure 1.

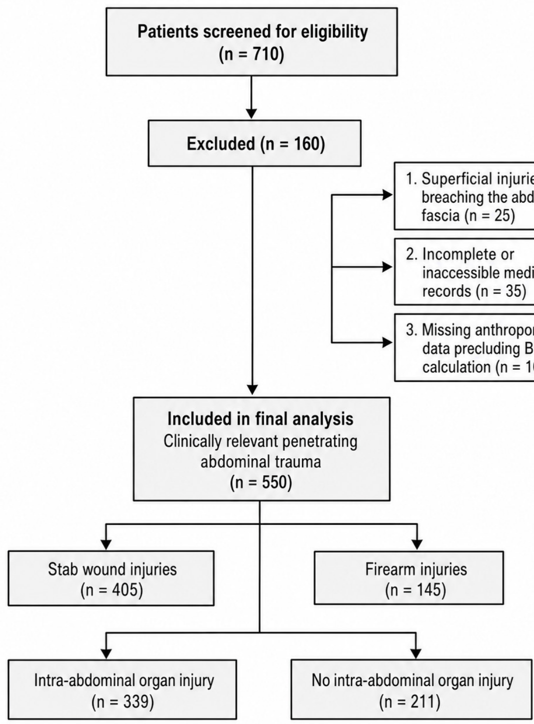

Figure 1. Study flow diagram illustrating patient selection, eligibility, exclusions, and inclusion in the final analysis cohort (710 screened; 25 superficial injuries, 35 inaccessible records, and 100 missing BMI data excluded; 550 included)

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Data Collection and Variable Definitions

Patient demographics, injury type, admission condition, imaging findings, surgical reports, and hospital outcomes were extracted from the electronic medical records and trauma registry.

Shock at presentation was defined as systolic blood pressure < 90 mmHg and/or clinical documentation of hemodynamic instability requiring immediate resuscitation.

BMI was calculated as weight in kilograms divided by height in meters squared. The World Health Organization (WHO) categories were used to describe BMI: underweight, normal weight, overweight, and obese. For the primary multivariable regression model, obesity was coded as a binary exposure variable, defined as BMI $\geq$ 30 kg/m². Non-obese patients, including underweight, normal-weight, and overweight patients, served as the reference group. BMI was also analyzed as a continuous variable for predictive purposes in sensitivity analyses. Injury was determined based on operative or radiologically confirmed findings that required management.

For the secondary analyses, injuries were categorized as follows:

- Solid organ injury (liver, spleen, kidney, pancreas)
- Hollow viscus injury (stomach, small bowel, colon)

Non-therapeutic laparotomy was defined as operative exploration without the identification of a surgically relevant intra-abdominal injury.

Sample Size Considerations

Because this was a retrospective study, we did not calculate the sample size in advance. We included all eligible patients from the study period to improve accuracy and reduce bias.

To ensure model stability, we limited the number of candidate predictors according to the events-per-variable principle. The ratio of outcomes to covariates exceeded the recommended thresholds, thereby reducing the risk of overfitting. Penalized regression was used to address small-sample bias and quasi-separation.

Handling of Missing Data

Data completeness was verified prior to analysis. After exclusion of patients with missing BMI data, missingness in the remaining analytic variables was less than 5%, and missingness was not associated with BMI groups. Only cases with complete data for the variables included in each model were analyzed.

A comparison of cases with complete data to all available cases revealed no substantial differences in patient characteristics or outcomes, supporting the reliability of the dataset.

Statistical Analysis

Continuous variables are reported as mean ± standard deviation or median with interquartile range, depending on the distribution. Categorical variables are presented as counts and percentages. Between-group comparisons were performed using the χ^2 test or Fisher's exact test for categorical variables and the Student's t-test or Mann – Whitney U test for continuous variables, as appropriate. A two-sided p value of < 0.05 was considered statistically significant.

Multivariable Modelling

To evaluate the independent association between obesity and intra-abdominal organ injury, multivariable logistic regression models were constructed, adjusting for the mechanism of injury (stab vs. firearm) and the presence of shock at admission. Additional clinically available covariates, including age, sex, number of entry wounds, systolic blood pressure, and Glasgow Coma Scale score on arrival, were incorporated in the expanded model presented in Table 3 to reduce residual confounding.

Because conventional maximum likelihood logistic regression showed instability and potential quasi-separation, penalized (Firth) logistic regression was applied in the primary models. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. Wald χ^2 statistics were used for hypothesis testing.

Separate multivariate models were constructed for:

1. Any intra-abdominal organ injury
2. Solid organ injury
3. Hollow viscus injury

Formal interaction testing between the BMI and the mechanism of injury was performed.

Model Discrimination and Calibration

Model discrimination was assessed using receiver operating characteristic (ROC) curve analysis. The area under the curve (AUC) was calculated, with 95% confidence intervals derived using bootstrap resampling (1,000 iterations).

Calibration was evaluated using decile-based grouping of predicted probabilities and the Hosmer – Lemeshow χ^2 statistic. Calibration plots were generated by comparing the observed and predicted event rates across the risk strata.

Sensitivity Analyses

Several sensitivity analyses were performed to assess robustness.

1. Re-estimation of models using conventional maximum likelihood logistic regression
2. Evaluation of BMI as both a categorical and continuous variable
3. Subgroup analyses stratified by injury mechanism (stab wounds and firearm injuries analyzed separately).
4. Injury-pattern-specific modelling of solid and hollow viscus injuries

Across these analyses, the direction and magnitude of the effect estimates were examined for consistency.

Analytical Framework

Because penetrating trauma causes direct damage along a set path rather than distributing force, the analysis was structured to determine whether measures, such as body mass index, could predict injury risk beyond injury type and patient condition.

We adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

All key checklist items, such as study design, participant selection, variable definitions, statistical methods, and reporting of results, were included.

Results

During the study period, 710 patients were screened; 25 patients with isolated superficial injuries, 35 patients whose medical records could not be accessed, and 100 patients with missing BMI data were excluded, leaving 550 patients for the final analysis. The average age was 34.7 years, and the cohort predominantly consisted of male patients, with 486 men (88.4%). Based on WHO BMI categories, 36 patients (6.5%) were underweight, 266 (48.4%) were normal weight, 180 (32.7%) were overweight, and 68 (12.4%) were obese. Approximately 61.6% (339/550) had organ injury, with 32.0% having solid organ injuries and 36.4% having hollow viscus injuries. Table 1 shows patient and injury details by BMI group.

The distribution of organ injury patterns across BMI categories did not differ significantly ($p = 0.41$ for any organ injury; $p = 0.47$ for solid organ injury; $p = 0.52$ for hollow viscus injury). Similarly, the number of injured organs per patient was not associated with the BMI group ($p = 0.58$) (Table 2).

Penalized (Firth) multivariate logistic regression adjusting for the mechanism of injury (stab vs. firearm), presence of shock at admission, age, sex, number of entry wounds, systolic blood pressure, and Glasgow Coma Scale score on arrival demonstrated no independent association between obesity and intra-abdominal organ injury (adjusted OR 1.33, 95% CI 0.75 – 2.34, $p = 0.33$) (Table 3). Neither the injury mechanism nor admission shock modified the association between BMI and organ injury, and formal BMI×mechanism interaction testing was not statistically significant ($p = 0.71$). In mechanism-stratified analyses, obesity was not associated with intra-abdominal organ injury in the stab wound subgroup (OR 1.05, 95% CI 0.56 – 1.96, $p = 0.878$), whereas the firearm subgroup showed a higher point estimate but wide confidence intervals crossing the null value (OR 4.09, 95% CI 0.83 – 20.19, $p = 0.084$), indicating limited precision.

Table 1. Baseline characteristics

Variable	Underweight	Normal	Overweight	Obese
N	36	266	180	68
Age, years (median [IQR])	32.0 (25.5 – 38.5)	32.0 (25.0 – 39.0)	30.5 (23.0 – 37.0)	27.0 (21.0 – 40.0)
BMI, kg/m² (median [IQR])	17.1 (16.3 – 17.8)	22.3 (20.5 – 23.6)	27.1 (25.9 – 28.1)	31.6 (30.8 – 33.0)
Number of entry wounds (median [IQR])	2.0 (1.0 – 2.0)	2.0 (1.0 – 2.0)	2.0 (1.0 – 2.0)	1.0 (1.0 – 2.0)
GCS on arrival (median [IQR])	15.0 (14.0 – 15.0)	15.0 (14.0 – 15.0)	15.0 (14.0 – 15.0)	15.0 (14.0 – 15.0)
SBP on arrival, mmHg (median [IQR])	105.0 (91.8 – 119.8)	112.0 (95.0 – 127.0)	108.0 (93.0 – 122.0)	113.5 (95.8 – 124.0)
Heart rate on arrival, bpm (median [IQR])	98.5 (89.5 – 114.5)	93.0 (83.0 – 107.0)	95.0 (81.0 – 109.0)	90.5 (82.0 – 110.8)
Male sex	35 (97.2%)	253 (95.1%)	155 (86.1%)	43 (63.2%)
Mechanism: stab wound	23 (63.9%)	202 (75.9%)	126 (70.0%)	54 (79.4%)
Mechanism: firearm	13 (36.1%)	64 (24.1%)	54 (30.0%)	14 (20.6%)
Shock on arrival	13 (36.1%)	60 (22.6%)	48 (26.7%)	16 (23.5%)
FAST positive	13 (36.1%)	112 (42.1%)	73 (40.6%)	27 (39.7%)
CT performed	10 (27.8%)	92 (34.6%)	51 (28.3%)	26 (38.2%)
Laparotomy performed	26 (72.2%)	188 (70.7%)	142 (78.9%)	52 (76.5%)
Laparoscopy performed	2 (5.6%)	25 (9.4%)	18 (10.0%)	8 (11.8%)
Conservative management	8 (22.2%)	53 (19.9%)	20 (11.1%)	8 (11.8%)

BMI: Body Mass Index, GCS: Glasgow Coma Scale, SBP: Systolic Blood Pressure, FAST: Focused Assessment with Sonography for Trauma, CT: Computed Tomography; Continuous variables are presented as median (IQR); Categorical variables as n (%); Kruskal–Wallis test for continuous variables; Chi-square/ Fisher's exact test for categorical variables

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Table 2. Organ injury patterns

Variable	Underweight	Normal	Overweight	Obese
Any intra-abdominal organ injury	22 (61.1%)	167 (62.8%)	104 (57.8%)	46 (67.6%)
Solid organ injury (liver/spleen/kidney/pancreas)	12 (33.3%)	86 (32.3%)	54 (30.0%)	24 (35.3%)
Hollow viscus injury (stomach/small bowel/colon)	11 (30.6%)	100 (37.6%)	54 (30.0%)	35 (51.5%)
Liver injury	6 (16.7%)	60 (22.6%)	33 (18.3%)	14 (20.6%)
Spleen injury	4 (11.1%)	26 (9.8%)	17 (9.4%)	8 (11.8%)
Kidney injury	2 (5.6%)	11 (4.1%)	8 (4.4%)	7 (10.3%)
Pancreatic injury	1 (2.8%)	2 (0.8%)	1 (0.6%)	0 (0.0%)
Stomach injury	1 (2.8%)	21 (7.9%)	11 (6.1%)	6 (8.8%)
Small bowel injury	7 (19.4%)	68 (25.6%)	36 (20.0%)	22 (32.4%)
Colon injury	5 (13.9%)	25 (9.4%)	16 (8.9%)	11 (16.2%)
Bladder injury	2 (5.6%)	12 (4.5%)	6 (3.3%)	3 (4.4%)
Vascular injury	2 (5.6%)	19 (7.1%)	14 (7.8%)	5 (7.4%)
Diaphragm injury	0 (0.0%)	5 (1.9%)	9 (5.0%)	2 (2.9%)
Number of injured organs (median [IQR])	1.0 (0.0 – 1.0)	1.0 (0.0 – 2.0)	1.0 (0.0 – 1.0)	1.0 (0.0 – 2.0)

Any intra-abdominal organ injury was defined as injury to liver, spleen, stomach, small bowel, colon, kidney, pancreas, bladder, vascular structures, or diaphragm; Solid organ: liver, spleen, kidney, pancreas; Hollow viscus: stomach, small bowel, colon; Statistical comparisons by Chi-square and Kruskal–Wallis tests

Table 3. Penalized (Firth) multivariable logistic regression analysis for any intra-abdominal organ injury, including stratified analyses by injury mechanism

Predictor	Overall OR (95% CI)	Overall p	Stab OR (95% CI)	Stab p	Firearm OR (95% CI)	Firearm p
Obesity	1.33 (0.75 – 2.34)	0.33	1.05 (0.56 – 1.96)	0.878	4.09 (0.83 – 20.19)	0.084
Firearm	1.10 (0.74 – 1.64)	0.629	Not applicable	Not applicable	Not applicable	Not applicable
Age	1.00 (0.98 – 1.02)	0.942	1.00 (0.98 – 1.02)	0.975	1.01 (0.97 – 1.04)	0.734
Male sex	0.94 (0.53 – 1.67)	0.833	0.95 (0.50 – 1.82)	0.885	0.91 (0.25 – 3.30)	0.881
Number of entry wounds	1.10 (0.89 – 1.36)	0.362	1.12 (0.89 – 1.42)	0.327	1.04 (0.62 – 1.75)	0.882
Shock on arrival	0.71 (0.44 – 1.15)	0.167	0.71 (0.41 – 1.26)	0.242	0.74 (0.30 – 1.87)	0.529
Systolic blood pressure on arrival	1.00 (0.99 – 1.01)	0.81	1.00 (0.99 – 1.01)	0.539	1.01 (0.99 – 1.03)	0.537
GCS on arrival	1.05 (0.94 – 1.17)	0.422	1.06 (0.94 – 1.20)	0.37	1.04 (0.81 – 1.33)	0.751

Multivariable logistic regression performed with any intra-abdominal organ injury as dependent variable; Results presented as adjusted OR with 95% CI; Stratified models constructed for stab and firearm injuries

Subgroup analyses demonstrated similar findings. In penalized (Firth) multivariate modelling for solid organ injury, obesity was not independently associated with altered risk (adjusted OR 1.02, 95% CI 0.69 – 1.49, p = 0.92). Adjustment for injury mechanism and shock status did not materially change the effect estimates, and no significant interaction between BMI and mechanism was observed. Penalized (Firth) multivariate logistic regression for hollow viscus injury similarly demonstrated no independent association between obesity and injury occurrence (adjusted OR 1.11, 95% CI 0.73 – 1.69, p = 0.62). The effect estimates remained stable following adjustment, and no evidence of mechanism-specific modification was identified. A forest plot of the multivariate model for any organ injury is shown in Figure 2.

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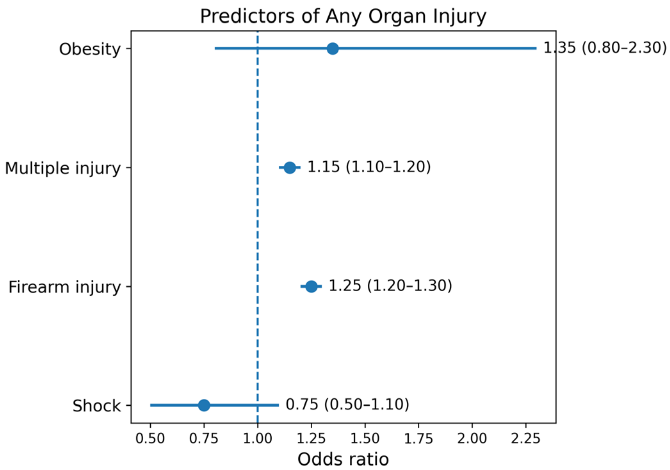

Figure 2. Forest plot demonstrating independent predictors of any organ injury in patients with penetrating trauma; Odds ratios (ORs) with 95% confidence intervals (CIs) are shown for each variable included in the multivariate logistic regression model; The dashed vertical line represents the null effect (OR = 1)

As a supportive secondary analysis, ROC analysis evaluating BMI as a standalone predictor demonstrated poor discriminatory performance for any intra-abdominal organ injury, with an AUC of 0.51 (95% confidence interval [CI] 0.46 – 0.56) derived from 1,000 bootstrap iterations (Figure 3). BMI alone demonstrated similarly poor discrimination for solid organ injury (AUC 0.50) and hollow viscus injury (AUC 0.52), indicating that BMI does not meaningfully distinguish between injured and non-injured patients with penetrating abdominal trauma.

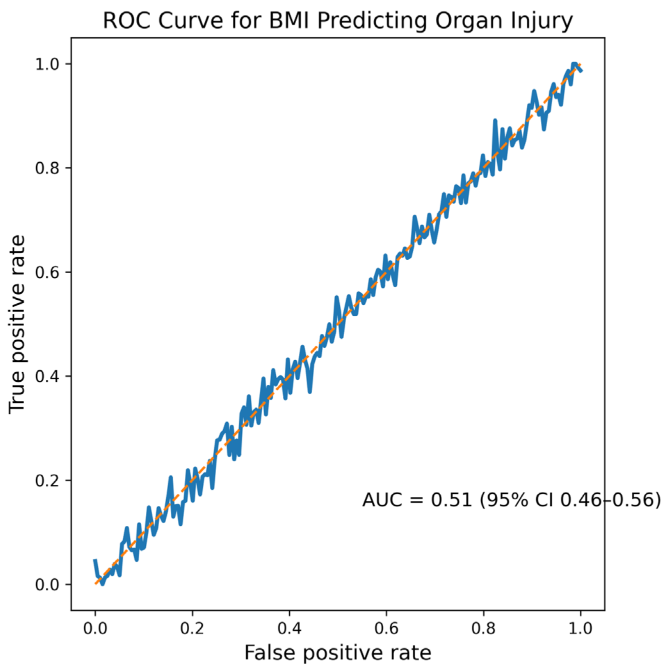

Figure 3. Receiver operating characteristic (ROC) curve evaluating the supportive secondary performance of body mass index (BMI) in predicting the presence of organ injury following penetrating trauma; The area under the curve (AUC) was 0.51 (95% CI 0.46–0.56), indicating no discriminative ability; The dashed diagonal line represents the line of no discrimination

Calibration analysis using decile-based predicted probability stratification did not demonstrate clinically meaningful separation between predicted and observed risk across probability strata (Figure 4). The Hosmer – Lemeshow goodness-of-fit test did not indicate a significant lack of fit ($p > 0.05$). These findings indicate that BMI lacks both discriminatory and calibration performance as a predictive marker in this clinical context.

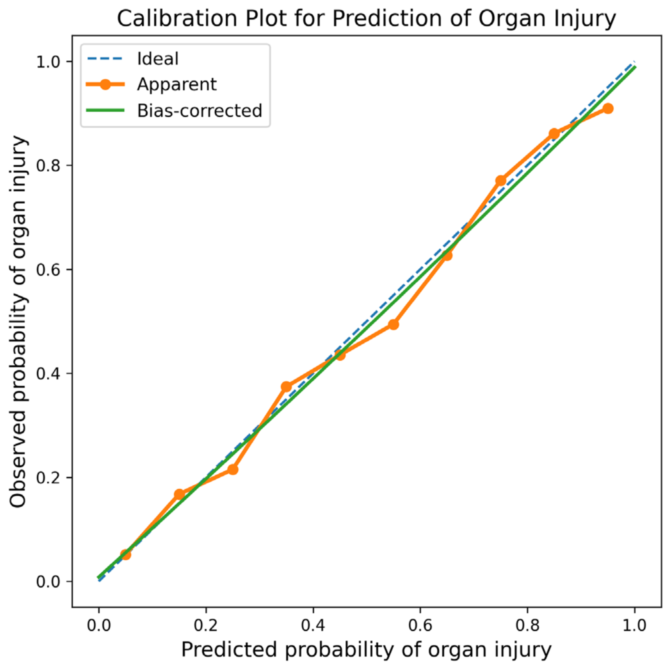

Figure 4. Calibration plot assessing the agreement between the predicted and observed probabilities of organ injury; The apparent model is shown together with the bias-corrected curve derived from bootstrap resampling; The dashed line indicates ideal calibration

Operative management was performed in 461 patients (83.8%), including laparotomy in 408 patients and laparoscopy in 53 patients. Non-therapeutic laparotomy occurred in 11.8% of operative cases and was not associated with BMI category ($p = 0.59$). In the penalized (Firth) multivariate logistic regression, obesity was not independently associated with non-therapeutic laparotomy (adjusted OR 1.12, 95% CI 0.71 – 1.78, $p = 0.63$).

Overall, across multiple analytical approaches, no evidence was found to support that obesity protects against organ injury or influences surgical outcomes in penetrating abdominal trauma.

Discussion

This study provides clinically focused evidence that obesity does not confer visceral protection in clinically relevant penetrating abdominal trauma. Multiple analytical methods have demonstrated no association between BMI and organ injury. These findings challenge the applicability of the obesity paradox observed in blunt trauma to penetrating injuries. Few studies have evaluated the predictive value of BMI. Because isolated superficial injuries were excluded, the present findings should be interpreted as addressing visceral injury after clinically relevant penetrating trauma rather than protection against fascial penetration.

Blunt trauma research provides a plausible mechanical explanation for the potential attenuation of injury severity in individuals with increased adiposity. Greater subcutaneous tissue thickness may theoretically reduce the transmission of kinetic energy to intra-abdominal structures and influence the distribution of solid organ injuries. However, this proposed protective mechanism remains inconsistent across clinical contexts, particularly in injuries involving hollow viscera and mesenteric structures. Moreover, the applicability of such biomechanical considerations to penetrating trauma is uncertain, as tissue disruption in these injuries is primarily determined by wound trajectory, energy transfer, and weapon characteristics. These uncertainties highlight the need for a mechanism-specific evaluation of anthropometric factors in trauma populations.

However, the evidence remains mixed, and some studies have failed to demonstrate a consistent protective effect of obesity across abdominal injury subtypes [7]. This suggests that any cushioning effect is injury-type-dependent. Even in blunt trauma, increased adiposity does not consistently protect all organs. Therefore, caution is warranted when extrapolating this concept to penetrating trauma.

Penetrating abdominal trauma is different in how it causes damage. Instead of dispersing energy through the tissues, the injury follows a set path. In stab wounds, the damage is along a narrow line created by the blade. In gunshot wounds, the damage depends on the speed and movement of the bullet. For body fat to protect the organs, it would need to change the depth or path of the injury before it reaches the organs; however, this effect may be too small or inconsistent to be noticeable in most patients.

Our findings align with contemporary literature on penetrating trauma. A Level I trauma centre analysis reported no protective association between BMI and organ injury severity following penetrating trauma [8]. Recent trauma literature has consistently reported heterogeneous associations between body mass index and injury severity or clinical outcomes, indicating that anthropometric measures alone provide limited prognostic value when mechanism-specific and physiological variables are incorporated into risk assessment models [9,10].

In addition, contemporary retrospective analyses evaluating the relationship between obesity and trauma outcomes have reported inconsistent associations between body mass index and clinically relevant endpoints, such as injury severity, operative intervention, and mortality. These findings suggest that BMI alone may be an insufficient surrogate for body composition or injury susceptibility in trauma populations, particularly when mechanism-specific injury factors are considered [11].

Contemporary trauma guidelines emphasise that in penetrating abdominal injuries, wound trajectory, energy transfer, and haemodynamic status are the principal determinants of visceral injury and operative decision-making [12]. The findings of the present study align with this mechanism-driven framework, showing that body mass index did not provide meaningful predictive value for organ injury, even after interaction analyses and model performance assessment. These results should be interpreted with caution; however, as the relatively small number of firearm injuries in the present cohort may have limited statistical power for subgroup analyses and contributed to the wide confidence intervals observed in this category. The mechanism-stratified findings further support this interpretation for stab wounds; however, the firearm subgroup should be considered exploratory because firearm injuries are biomechanically distinct and the corresponding confidence intervals were wide.

Notably, no significant interaction was identified between BMI and injury type. Although it could be hypothesized that body fat might confer greater protection in lower-energy injuries, such as stab wounds, compared to gunshot wounds, this analysis did not support this. These findings suggest that body fat exerts minimal influence relative to the direct trajectory of injury in penetrating trauma.

The ROC analysis was retained as a supportive assessment of BMI performance rather than as a primary prediction-model objective. It further confirmed that BMI is not useful for risk prediction in penetrating abdominal trauma. The AUC was 0.51 (95% CI, 0.46 – 0.56), indicating discrimination no better than chance. Calibration analysis similarly failed to demonstrate meaningful separation across predicted probability strata. These findings indicate that BMI lacks both discriminatory and calibration performance for risk modelling in this setting.

The operative findings provide an additional layer of validation. If obesity confers visceral protection, one might expect obese patients to exhibit higher rates of non-therapeutic laparotomy, reflecting fewer intra-abdominal injuries despite concerning wound patterns. However, no such association was observed. This is consistent with widely adopted practice management guidelines for penetrating abdominal trauma, which prioritise haemodynamic status, injury mechanism, and imaging findings rather than anthropometric characteristics in operative decision-making [13].

This study has several strengths. Penalized multivariate modeling was utilized to reduce bias associated with small sample sizes. The interactions between BMI and injury type were formally tested. Both discrimination and calibration were assessed to comprehensively evaluate the predictive value of BMI. Additionally, solid and hollow organ injuries were analyzed separately to enhance interpretability.

This study has several important strengths; however, it has limitations. First, as a single-center, retrospective study, the generalizability of the findings may be limited. Second, isolated superficial injuries not breaching the abdominal fascia were excluded; therefore, this study cannot determine whether obesity reduces the likelihood of fascial penetration or confines injury to superficial tissues. Third, BMI was used as a surrogate for body

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fat, which does not account for fat distribution or abdominal wall thickness; imaging-based measures may provide more precise information. However, the absence of an association between BMI and injury across multiple analyses suggests that body fat is unlikely to exert a meaningful effect on these injuries. Fourth, residual confounding from wound location, injury trajectory, number of wounds, weapon characteristics, anterior versus posterior involvement, prehospital care, and initial peritoneal or imaging findings cannot be fully excluded. Nonetheless, the lack of interaction between BMI and injury type reduces the likelihood of a missed protective effect. Although the sample size was sufficient for a stable analysis, very small effects cannot be entirely excluded. Finally, the firearm subgroup was relatively small, and firearm-specific findings should be interpreted as exploratory rather than definitive.

From a clinical perspective, these findings indicate that BMI does not influence risk stratification or operative decision-making in penetrating abdominal trauma. Instead, management should continue to rely on hemodynamic status, injury mechanism, wound characteristics, and imaging findings. The absence of a protective effect of obesity reinforces the importance of established trauma assessment algorithms and supports a mechanism-driven rather than anthropometry-driven approach to care. These findings support ongoing shifts toward physiology- and mechanism-driven trauma algorithms and reinforce the limited role of static anthropometric indicators in modern trauma decision-making frameworks [14].

Conclusion

In this cohort of patients with clinically relevant penetrating abdominal trauma, obesity was not associated with a reduced risk of intra-abdominal organ injury, and body mass index demonstrated limited predictive value for injury patterns or operative outcomes. Because isolated superficial injuries were excluded, the findings should not be interpreted as excluding a possible effect of adiposity on fascial penetration. These findings suggest that the obesity paradox described in blunt trauma may not apply to penetrating mechanisms. Clinical assessment and management should therefore remain focused on hemodynamic status, injury mechanism, wound characteristics, and imaging findings rather than anthropometric indicators, such as body mass index. Further multicenter studies incorporating detailed measures of abdominal adiposity are needed to clarify the relationship between body composition and injury risk in penetrating trauma.

Ethical Approval

This study was approved by the Non-Interventional Clinical Research Ethics Committee of Mersin City Training and Research Hospital (Approval No: 2026/131; Date: 25 February 2026).

Patient Consent

The requirement for informed consent was waived by the ethics committee due to the retrospective nature of the study and the use of anonymized patient data.

Conflict of Interest

The authors confirm the absence of any conflicts associated with this work.

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References

1. Owattanapanich N, Lewis M, Schellenberg M, et al. Impact of obesity on outcomes after abdominal gunshot injury. J Trauma Acute Care Surg. 2021;90:680-4.
2. Atkins K, Cairns B, Schneider A, Charles A. An evaluation of the “obesity paradox” in isolated blunt abdominal trauma in the United States. Injury. 2024;55:111612.
3. Chung JS, An S, Moon HE, et al. Association between obesity and intra-abdominal solid organ damage in patients with blunt abdominal trauma: a cross-sectional study. J Clin Med. 2024;13:7467.
4. Wang SC, Bednarski B, Patel S, et al. Increased depth of subcutaneous fat is protective against abdominal injuries in motor vehicle collisions. Annu Proc Assoc Adv Automot Med. 2003;47:545-59.
5. Ditillo M, Pandit V, Rhee P, et al. Morbid obesity predisposes trauma patients to worse outcomes: a National Trauma Data Bank analysis. J Trauma Acute Care Surg. 2014;76:176-9.
6. Varma D, Brown P, Clements W. Importance of the mechanism of injury in trauma radiology decision-making. Korean J Radiol. 2023;24:522-8.
7. Hsieh TM, Chuang PC, Liu CT, et al. Protective role of obesity on trauma impact: a retrospective analysis of patients with surgical blunt bowel mesenteric injury due to road traffic accidents. Risk Manag Healthc Policy. 2022;15:1533-43.
8. Yao A, Busso JI, Lakhi N. Obesity and penetrating trauma: outcomes from a level 1 trauma center in New York City. Open Access Emerg Med. 2024;16:107-15.
9. Brown CV, Velmahos GC. The consequences of obesity on trauma, emergency surgery, and surgical critical care. World J Emerg Surg. 2006;1:27.
10. Cromwell PM, Reynolds IS, Heneghan HM, Glasgow SM. Obesity and outcomes in trauma - a systematic review and meta-analysis. Injury. 2023;54:469-80.
11. Patel BM, Samsonov AP, Patel JR, et al. Obesity and anterior abdominal gunshot wounds: a cushion effect. Cureus. 2021;13:e19838.
12. Martin MJ, Brown CVR, Shatz DV, et al. Evaluation and management of abdominal gunshot wounds: A Western Trauma Association critical decisions algorithm. J Trauma Acute Care Surg. 2019;87:1220-7.
13. Como JJ, Bokhari F, Chiu WC, et al. Practice management guidelines for selective nonoperative management of penetrating abdominal trauma. J Trauma. 2010;68:721-33.
14. American College of Surgeons Committee on Trauma. Advanced Trauma Life Support: Student Course Manual. 10th ed. Chicago: American College of Surgeons. 2018.