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Retrospective Analysis of Blunt Abdominal Trauma and Seatbelt Sign: The Hollow Viscus Injury Predictor Score (HPS)

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This study was conducted under a protocol reviewed and approved by the San Antonio Military Medical Center Institutional Review Board and in accordance with the approved protocol.

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Background

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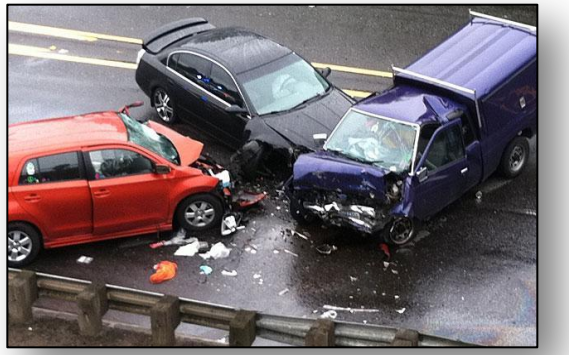
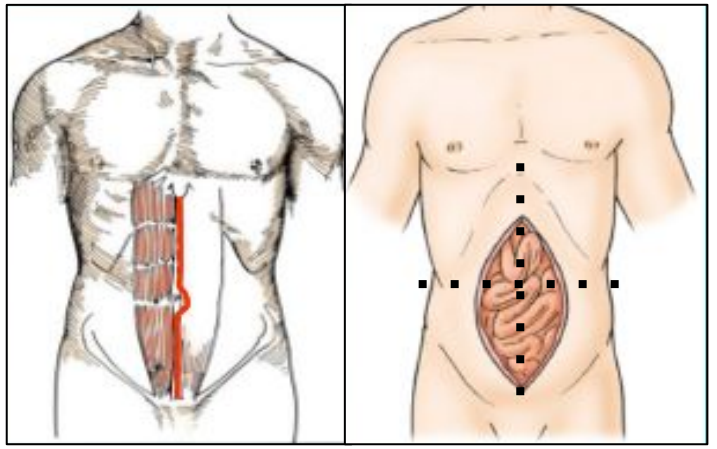
Key Terms

- Blunt Abdominal Trauma (BAT)
- Hollow Viscus Injury (HVI)
- Exploratory Laparotomy, also known as ex-lap
- Seatbelt Sign (SBS)





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Introduction

- Difficult to diagnose hollow viscus injury
- Management based on judgment
- Hollow viscus injury can be missed
  - High mortality (10-28%) & morbidity (44%)


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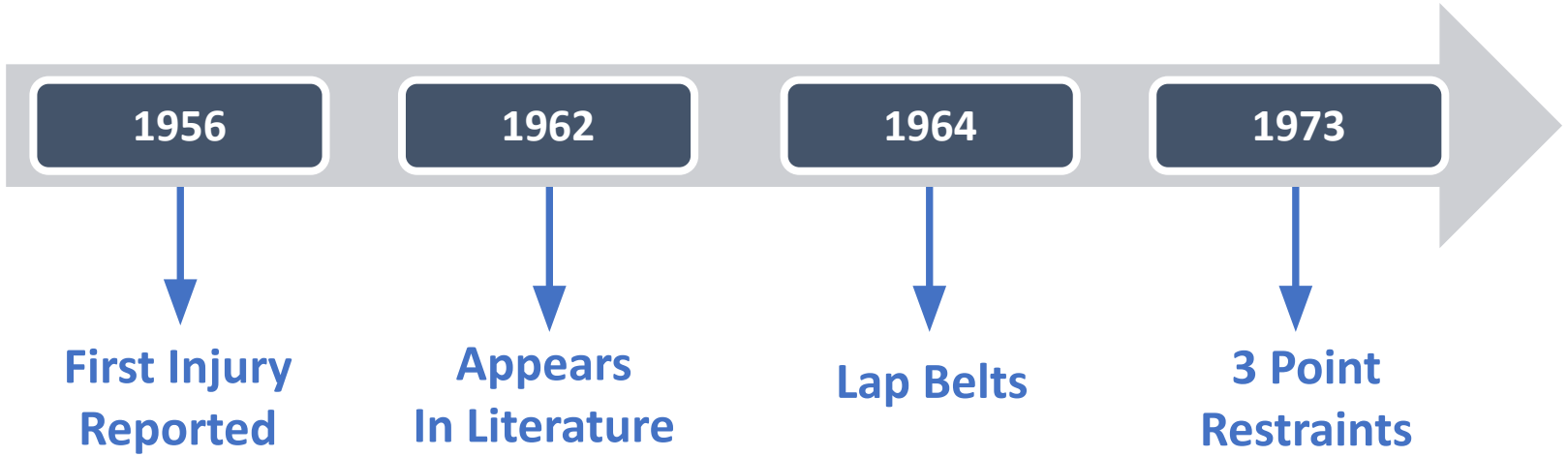
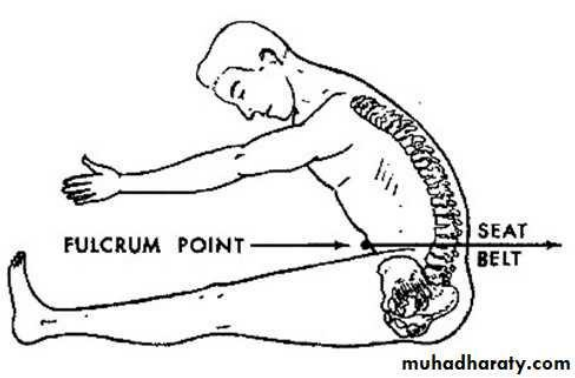
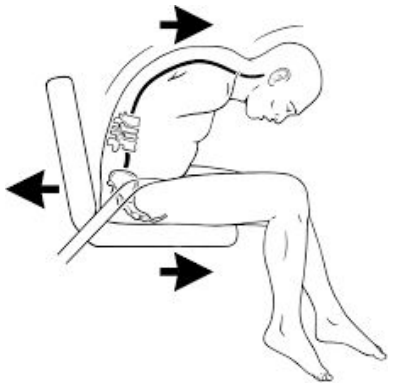
Background: Seatbelt Sign







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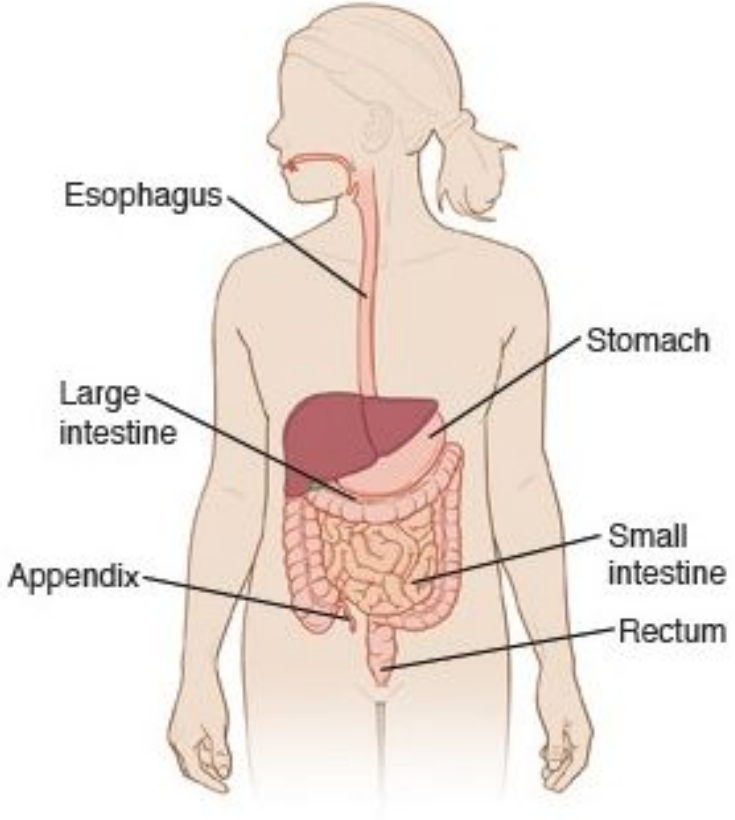
Seatbelt Sign

- Classic injury pattern
- 10-15% HVI incidence
- Most common HVI is in small bowel



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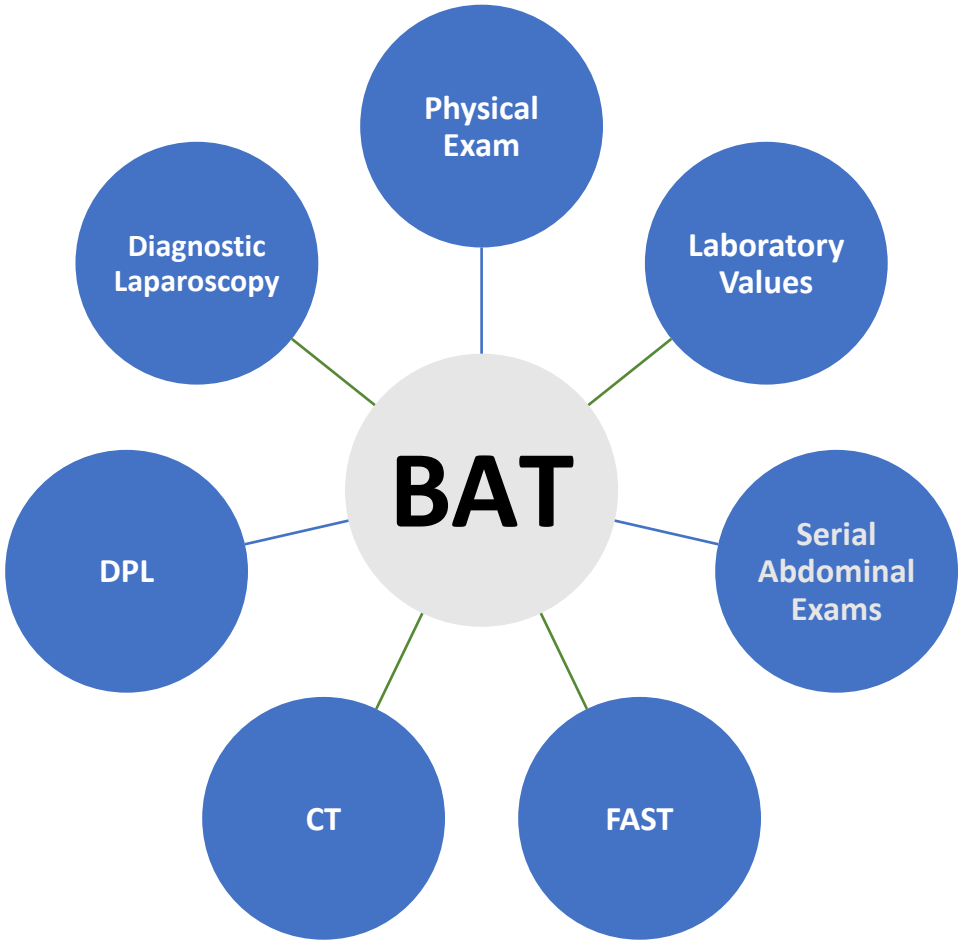
Background: Diagnosis



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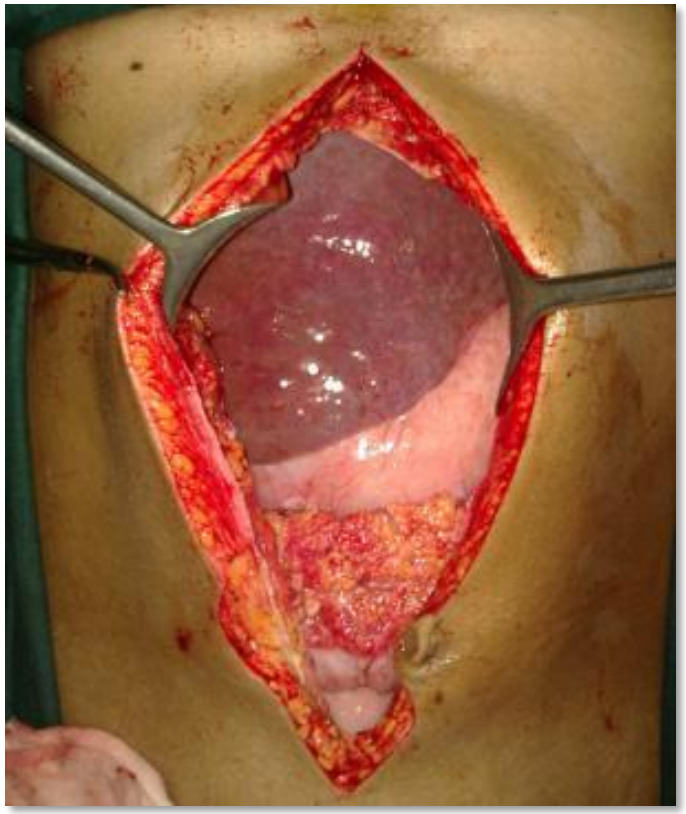
Background

- Exploratory laparotomy for unstable patients
- Nontherapeutic ex-lap rates up to 23-53% in BAT
- Role of nonoperative management



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Objectives

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The "WHY?"

- Lack of pathway to diagnose HVI
- Need for a tool to identify HVI

Determine if the hollow viscus injury predictor score (HPS) was higher in patients with a known hollow viscus injury (HVI)

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Methods

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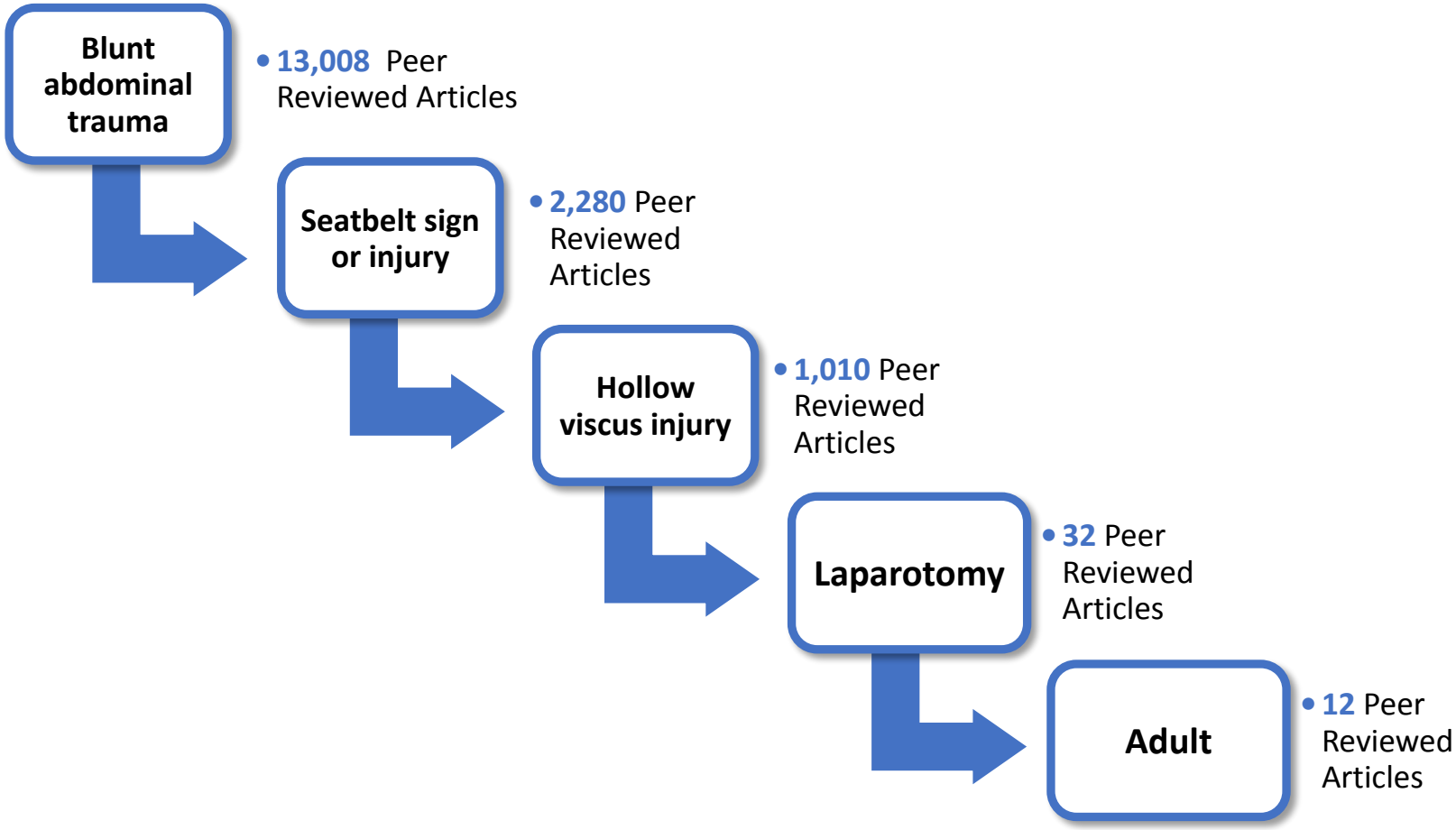
Literature Review



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Literature Review

The Journal of TRAUMA® Injury, Infection, and Critical Care

Colon Injury after Blunt Abdominal Trauma: Results of the EAST Multi-institutional Hollow Viscus Injury Study

Michael D. Williams, MD, Dorraine Watts, RN, PhD, and Samir Fakhry, MD

- Retrospective case-control study that examined 2,632 BAT patients matched by age and injury severity with a HVI compared to those without
- Admission exam, imaging, labs, and diagnostic modalities were examined alone and in combination
- Peritonitis 81% specific

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Literature Review

The use of computed tomography imaging for abdominal seatbelt sign: A single-center, prospective evaluation ☆

Patrick T. Delaplain [a,*], Cristobal Barrios [b], Dean Spencer [a], Michael Lekawa [b], Sebastian Schubl [b], Austin Dosch [a], Areg Grigorian [a], Megan Smith [c], Marija Pejcinovska [c], Jeffry Nahmias [b]

[a] Department of Surgery, University of California, Irvine Medical Center, United States
[b] Division of Trauma, Burns and Critical Care, University of California, Irvine Medical Center, United States
[c] Center for Statistical Consulting, University of California, Irvine, United States

- Prospectively examined 220 adult trauma patients admitted with an abdominal SBS
- Examined CT findings and other admission data (vital signs, exam, & labs) to identify HVI
- Hypotension and leukocytosis with HVI

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Literature Review

Early surgical intervention for blunt bowel injury: The Bowel Injury Prediction Score (BIPS)

Michelle K. McNutt, MD, Naga R. Chinapuvvula, MD, Nicholas M. Beckmann, MD, Elizabeth A. Camp, PhD, Matthew J. Pommerening, MD, Rece W. Laney, MS, O Clark West, MD, Brijesh S. Gill, MD, Rosemary A. Kozar, MD, PhD, Bryan A. Cotton, MD, MPH, Charles E. Wade, PhD, Phillip R. Adams, MD, *and* John B. Holcomb, MD, *Houston, Texas*

- Retrospectively examined 110 BAT patients
- Created the Bowel Injury Predictor Score (BIPS) to identify HVI
  - WBC ≥ 17, abdominal tenderness to palpation (TTP), and CT scan
- Leukocytosis & TTP significant in HVI

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HVI Predictor Score

- **Hypotension**
  - Delaplain: BP lower in HVI ($p < .001$)
- **Leukocytosis**
  - Delaplain: WBC count higher in HVI ($p = .013$)
  - McNutt: WBC ≥17 with HVI ($p = .003$)
- **Abnormal abdominal exam finding**
  - McNutt: tenderness (TTP) clinically significant ($p < .001$)
  - McNutt: TTP combined with elevated WBC □ HVI was 19x higher
  - Williams: peritonitis highly specific (81%)

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HVI Predictor Score

	Yes	No
SBP (≤ 110)	1	0
WBC (≥ 17)	1	0
Abnormal Abdominal Exam	1	0

HPS

Hypothesis:

Those **with a HVI** will have an **increased HPS** compared to those without (nHVI)

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Methods: Study Design

- **Single-center retrospective cohort analysis**
- All **adult** trauma patients (age 18 or older)
- Inclusion:
  - ≥ 18 years old
  - Blunt abdominal trauma with a seatbelt sign
- Exclusion:
  - Penetrating abdominal trauma
  - Pregnant
  - Emergency resuscitative thoracotomy
  - Death within 60 minutes of arrival
  - Surgery at an outside facility prior to arrival
  - Unstable needing emergency surgery

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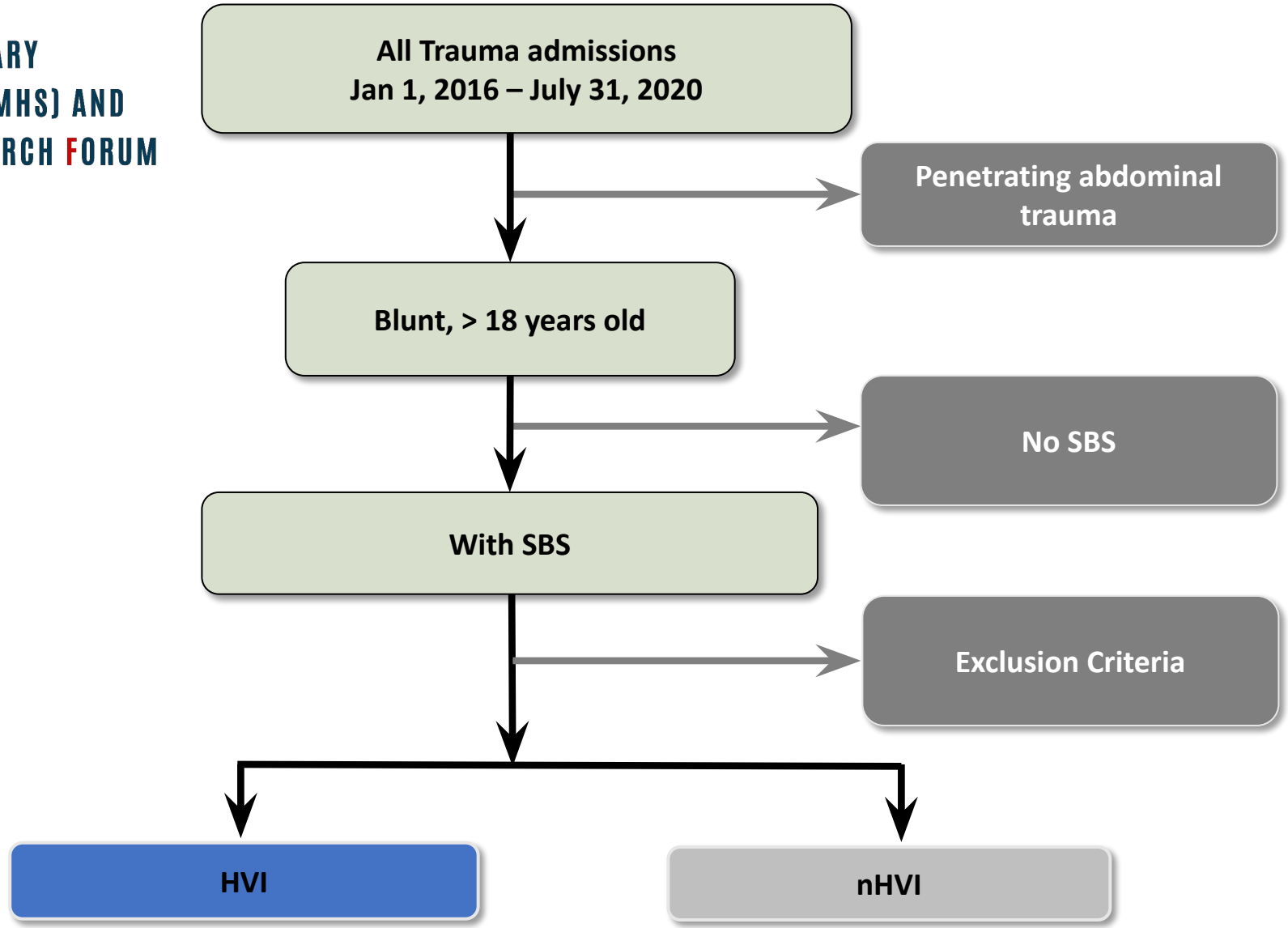

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Methods

- The dependent variable and primary outcome was **presence of HVI**
- Independent variable was our **HPS**
- Secondary Variables
  - Laparotomy
  - Abdominal pain
  - Specific abdominal exam findings

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Statistical Analysis

- Continuous data
  - Summarized using means and standard deviations or **medians** and **inter-quartile ranges**
  - Analyzed using **a Student's T-Test** and ANOVA or **Wilcoxon's Test**

- Categorical data
  - Summarized using **count and percentages**
  - Analyzed for association between the variables using **Chi-Squared** or Fisher's exact test

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Statistical Analysis

- **Logistical regression** was performed to determent independent prognostic factors for diagnosis of a HVI
  - Odds ratio with 95% Confident Interval (CI)

- **Receiver Operating Characteristic (ROC)** performed to analyze discrimination accuracy of independent variable
  - **Area under the curve (AUC)** with 95% CI

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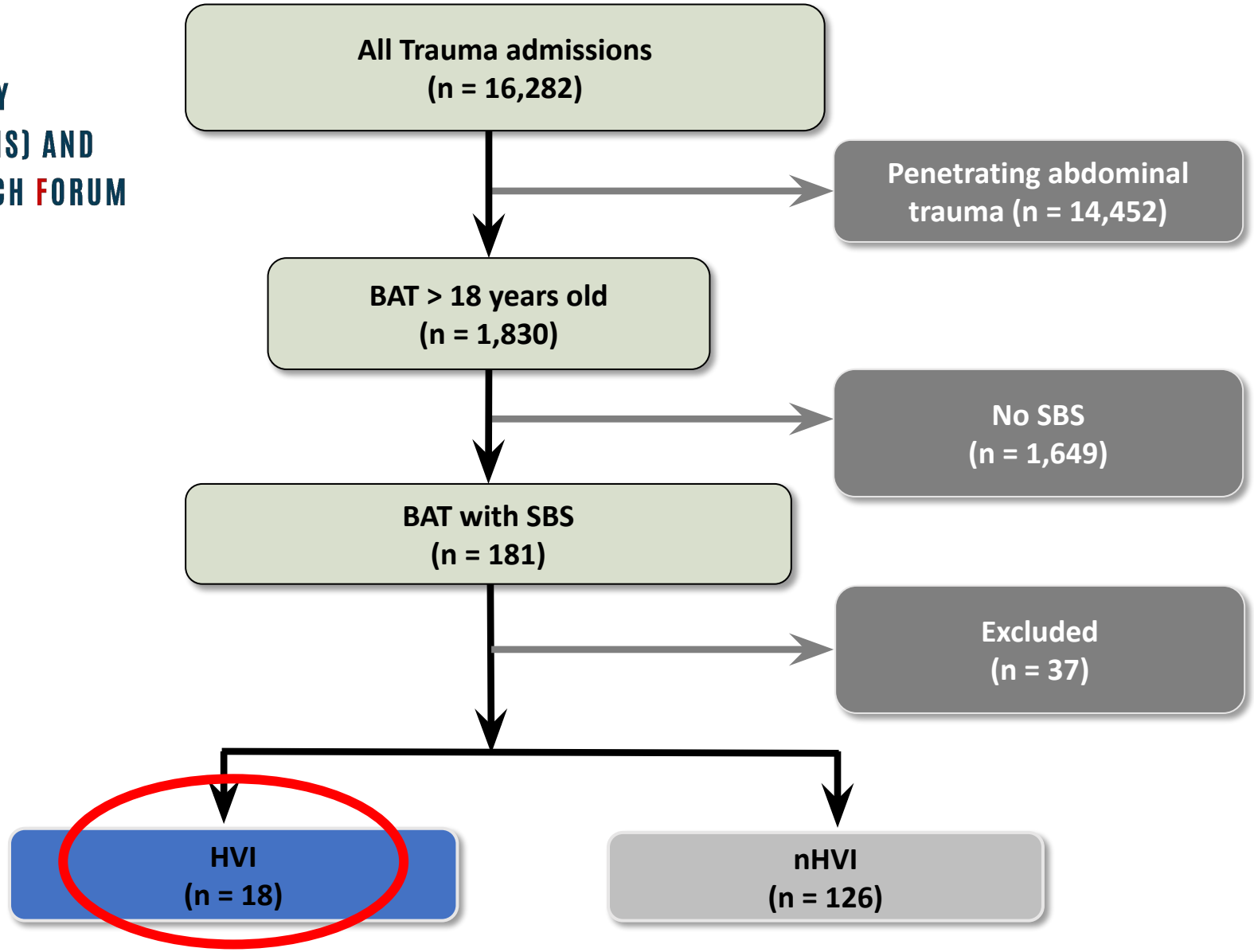

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Results

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Demographics

Demographics	*HVI (n = 18)*	*nHVI (n = 126)*	*p-value*
Age (y)	47.5	45.5	.686
Male (%)	9 (50)	63 (50)	1
BMI (kg/m^2)	32.02	32.77	.477
ISS	14.5	9	**. 002**

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Primary Outcome

	HVI (n = 18)	nHVI (n = 126)	P-value
HPS Score	1.28 ± .85	.82 ± .72	.008*

Data expressed as mean ± standard deviation
*Statistically significant ($p < .05$)

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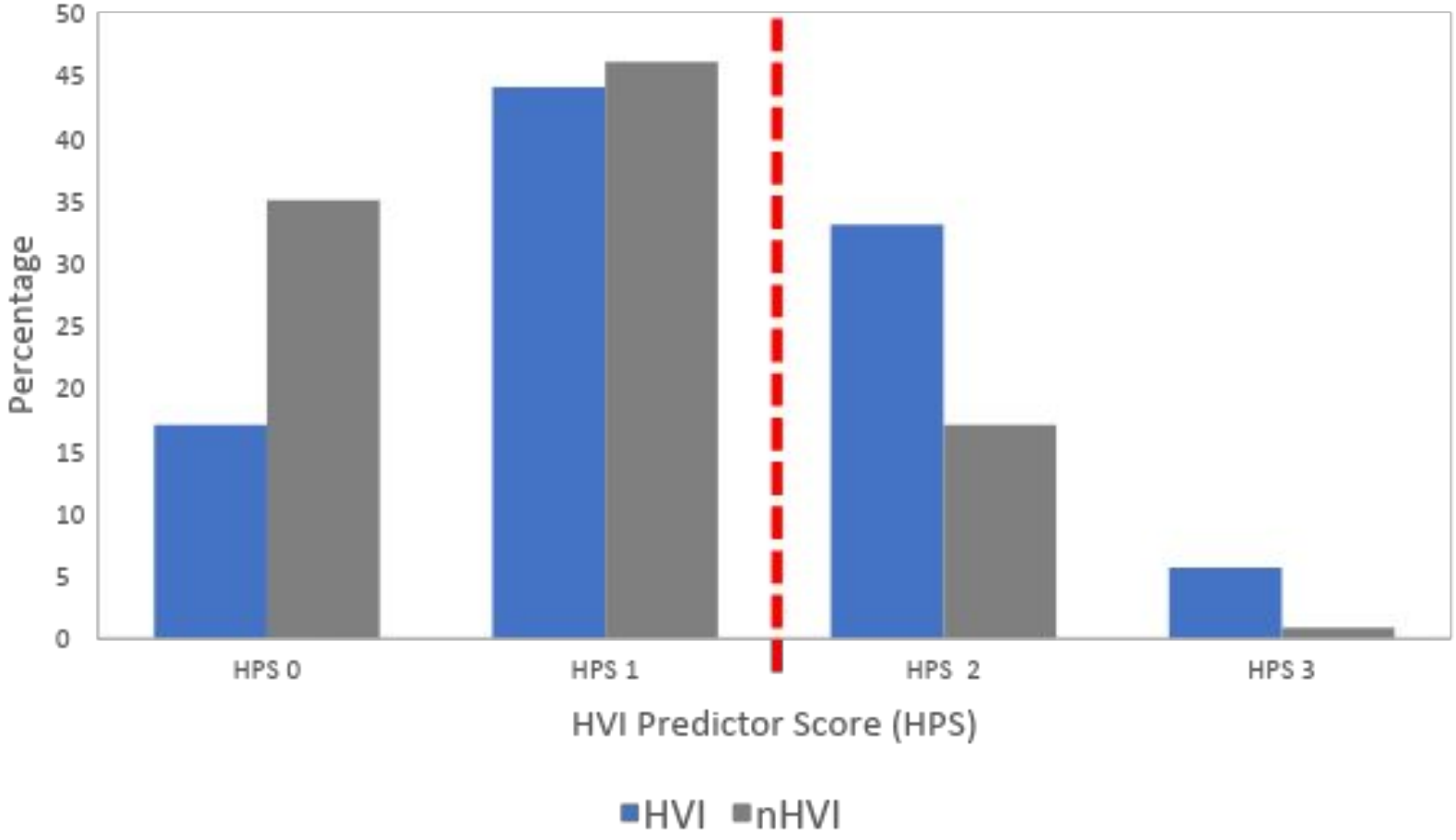
Secondary Outcomes



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Secondary Outcomes

	HPS 0 (n = 48)	HPS 1 (n = 66)	HPS ≥ 2 (n = 30)	P-value
HVI	3 (17)	8 (44)	7 (39)	.035*
nHVI	45 (35)	58 (46)	23 (18)	

Note. Each cohort had 1 patient with HPS score of 3.

Data expressed as number (%)
*Statistically significant ($p < .05$)

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Secondary Outcomes

HPS Score	OR	95% CI	P-value	AUC
1 vs 0	3.47	(0.71 – 16.90)	.123	.665 (p = .042*)
≥ 2 vs 0	6.70	(1.29 – 34.88)	.024*	

*Statistically significant (p < .05)

Factor	OR	95% CI	P-value	AUC
ISS	1.01	(1.03 – 1.16)	.001*	.767 (p < .001*)
HPS				
1 vs 0	2.79	(.55 – 14.24)	.217	
≥ 2 vs 0	5.86	(1.08 – 31.76)	.040*	

*Statistically significant (p < .05)

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Secondary Outcomes

Cutoff Point	True Positives	True Negatives	Coordinates of the ROC curve			P-value
			Sensitivity	Specificity	False Positives	
1	16	44	89%	37%	63%	.136
≥ 2	7	103	39%	82%	18%	.233

Note. A HPS of ≥ 2 had a negative predictive value (NPV) of 90% and a positive predictive value (PPV) of 23% for a HVI.

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Discussion/Conclusion

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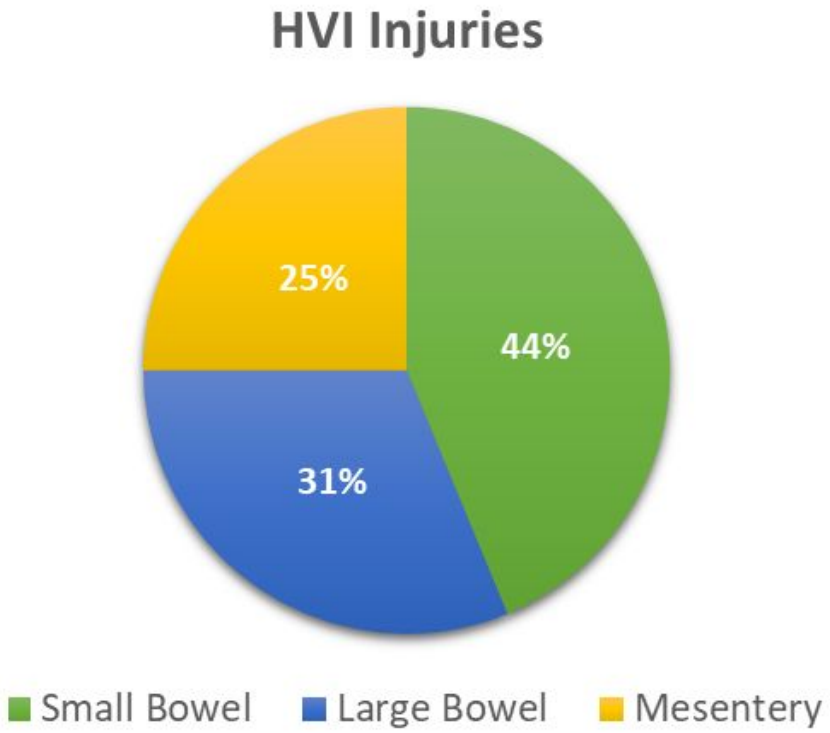
Discussion

	Literature	Ours
BAT	12%	11.2%
HVI in trauma	1%	1.1%
HVI in BAT with SBS	10-15%	12.5%



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Discussion

- HPS **higher** and **predictive** of HVI
- HPS ≥ 2 had an AUC .76 ($p < .001$)
  - Sensitivity 39%, specificity 82%, & NPV 90%
- BIPS ≥ 2 had AUC .81
  - Sensitivity 86%, specificity 76%, & NPV 89%

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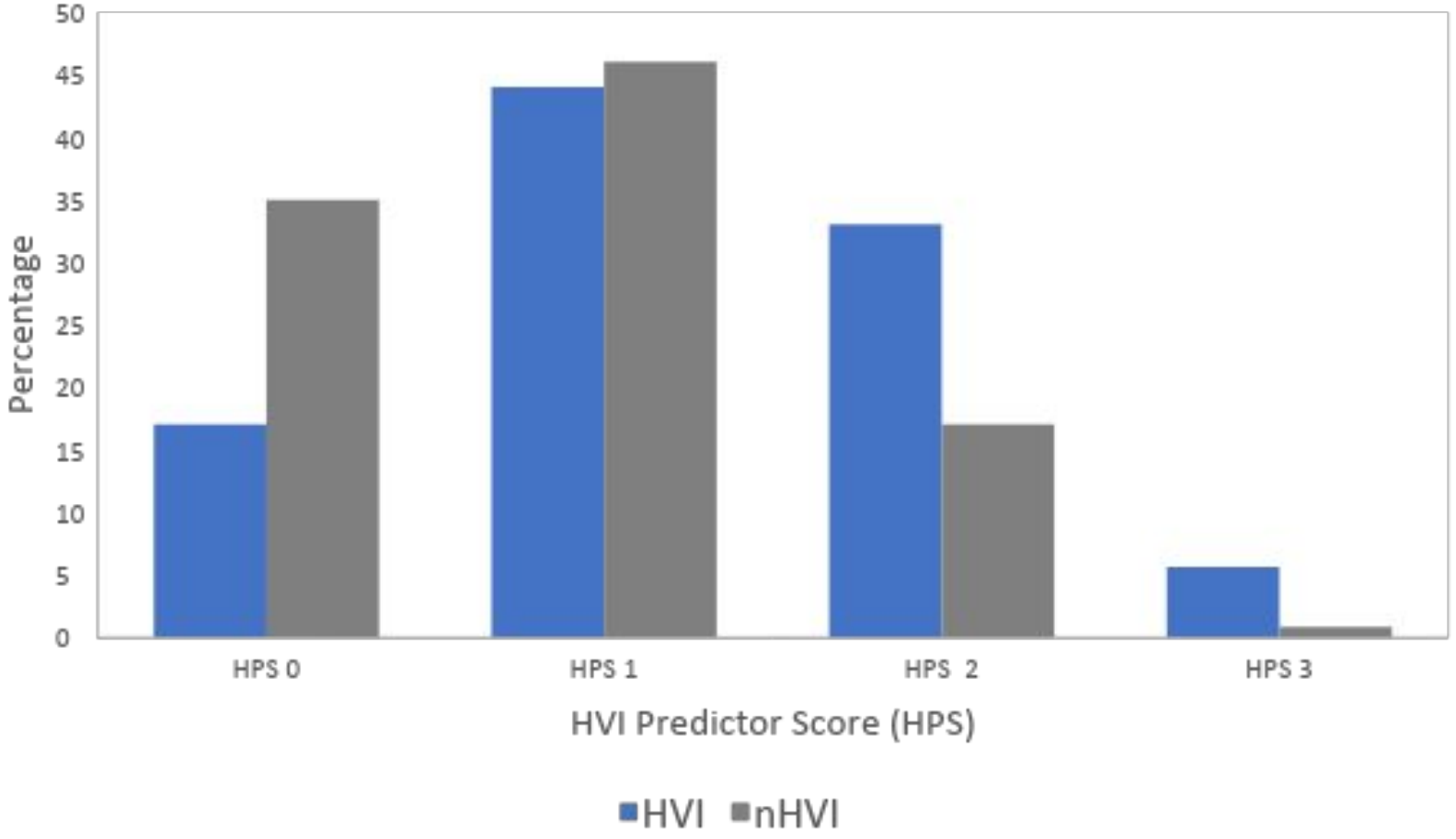
Secondary Outcomes



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Conclusion

- Fills the gap in literature
- Not only statistically significant, but clinically relevant
- HPS is a useful tool

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References

1. AlJaberi, Loay M., Alaa E. Salameh, Raha M. Almarzooqi, Mahammed F. Emar, and Rafiq Salhab. "Transection of the Appendix and Omentum Following a Seat Belt Injury; Case Report and Literature Review." *Annals of Medicine and Surgery* 34, (2018): 11–13.
2. Allen, Gary S., Frederick A. Moore, Charles S. Cox, Jr., Jason T. Wilson, Joseph M. Cohn, and James H. Duke. "Hollow Visceral Injury and Blunt Trauma." *The Journal of Trauma: and Acute Care Surgery* 45, no. 1 (1998): 69-77.
3. Allen, Todd L., Michelle T. Mueller, R. Thomas Bonk, Colleen P. Harker, Owen H. Duffy, and Mark H. Stevens. "Computed Tomographic Scanning without Oral Contrast Solution for Blunt Bowel and Mesenteric Injuries in Abdominal Trauma. *Journal of Trauma: Injury, Infection, and Critical Care* 56, no. 2 *(2004): 314-322.*
4. Anderson, Paul A., Frederick P. Rivara, Ronald V. Maier, and Christina Drake. "The Epidemiology of Seatbelt-Associated Injuries." *The Journal of Trauma: Injury, Infection, and Critical Care* 31, no. 1 (1991): 60-67.
5. Appleby, James P., and Alex G. Nagy. "Abdominal Injuries Associated with the Use of Seatbelts." *The American Journal of Surgery* 157, no. 5 (1989): 457–458.
6. Baker, Susan P., Brian O'Neill, William Haddon, Jr., and William B. Long. "The Injury Severity Score: A Method for Describing Patients with Multiple Injuries and Evaluating Emergency Care." *The Journal of Trauma: Injury, Infection, and Critical Care* 14, no. 3 (1974): 187-196.
7. Bansal, Vishal, Carol Conroy, Gail T. Tominaga, and Raul Coimbra. "The Utility of Seatbelt Signs to Predict Intra-Abdominal Injury Following Motor Vehicle Crashes." *Traffic Injury Prevention* 10, no. 6 (2009): 567-572.
8. Banz, Vanessa M., Muhammad U. Butt, Heinz Zimmermann, Victor Jeger, and Aristomenis K. Exadaktylos. "Free Abdominal Fluid without Obvious Solid Organ Injury upon CT Imaging: An Actual Problem or Simply Over-Diagnosing?" *Journal of Trauma Management and Outcomes* 3, no. 10 (2019): 10.
9. Barmparas, Galinos, Deven C. Patel, Nikhil T. Linaval, Navpreet K. Dhillon, Kavita A. Patel, Daniel R. Margulies, and Eric J. Ley. "A Negative Computed Tomography May Be Sufficient to Safely Discharge Patients with Abdominal Seatbelt Sign from the Emergency Department: A Case Series Analysis." *Journal of Trauma and Acute Care Surgery* 84, no. 6 (2018): 900–907.
10. Bennett, Sean, Aysah Amath, Heather Knight, and Jacinthe Lampron. "Conservative Management in Stable Patients with Penetrating Abdominal Trauma: The Experience of a Canadian Level 1 Trauma Centre." *Canadian Journal of Surgery* 59 no. 5 *(2016):* 317-321.
11. Biswas, Seema, Mohamed Adileh, Gidon Almogy, and Miklosh Bala. "Abdominal Injury Patterns in Patients with Seatbelt Signs Requiring Laparotomy." *Journal of Emergencies, Trauma, and Shock* 7, no. 4 (2014): 295-300.
12. "Clinical Practice Guidelines," Joint Trauma System: The Department of Defense Center of Excellence for Trauma, accessed August 10, 2021, https://jts.amedd.army.mil/index.cfm/PI_CPGs/cpgs.
13. Cohen, Barbara J. *The Human Body in Health and Disease.* 12th ed. Baltimore, Md: Lippincott, Williams, & Wilkins, 2013.
14. Coldwell, Christopher, and Ernest E. Moore. "Initial Evaluation and Management of Abdominal Gunshot Wounds in Adults." *UptoDate*.
15. Como, John J., Faran Bokhari, William C. Chiu, Therese M. Duane, Michele R. Holevar, Margaret A. Tandoh, Rao R. Ivatury, and Thomas M. Scalea. "Practice Management Guidelines for Selective Nonoperative Management of Penetrating Abdominal Trauma." *Journal of Trauma: Injury, Infection, and Critical Care 68, no. 3 (2010):* 721-733.
16. Cornelissen, Maarten P., Jesse van Buijtenen, Baukje van den Heuvel, Frank Bloemers, and Leo Geeraedts, Jr. "Blunt Abdominal Wall Disruption by Seatbelt Injury: A Case Report and Review of the Literature." *Bulletin of Emergency and Trauma* 4, no. 2 (2016): 105–109.
17. D'Elia, Michael A., R. Ian Grant, Nicole O. Kolozsvari, and Maher M. Matar. "Motor Vehicle Collision with Seatbelt Sign and Traumatic Abdominal Wall Hernia Should Raise Suspicion for Hollow Viscus Injury." *Trauma Case Reports* 22 (2019).
18. Delaplain, Patrick T., Cristobal Barrios, Dean Spencer, Michael Lekawa, Sebastian Schubl, Austin Dosch, Areg Grigorian, Megan Smith, Marija Pejcinovska, and Jeffry Nahmias. "The Use of Computed Tomography Imaging for Abdominal Seatbelt Sign: A Single-Center, Prospective Evaluation." *Injury* 51, no. 1 (2002): 26-31.
19. Demetriades, Demetrios, James A. Murray, Linda Chan, Carlos Ordoez, Douglas Bowley, Kimberly K. Hagy, Edward E. Cornwell, et al. "Penetrating Colon Injuries Requiring Resection: Diversion or Primary Anastomosis? An AAST Prospective Multicenter Study." *Journal of Trauma: Injury, Infection, and Critical Care* 50, no. 5 (2001): 765-775.

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References

20. "EAST Practice Management Guidelines," The Eastern Association for the Surgery of Trauma, accessed August 10, 2021, https://www.east.org.
21. Fakhry, Samir M., Dorraine D. Watts, and Fred A. Luchette. "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." *The Journal of Trauma: Injury, Infection, and Critical Care* 54, no. 2 (2003): 295-306.
22. Feliciano, David V. "Abdominal Trauma Revisited." *The American Surgeon* 2017: 1193-1202.
23. Glover, Julie M., Madelyn F. Waychoff, Monica Casmaer, Michael D. April, Curtis J. Hunter, Scott T. Trexler, and Lorne H. Blackbourne. "Association between Seatbelt Sign and Internal` Injuries in the Contemporary Airbag Era: A Retrospective Cohort Study." *The American Journal of Emergency Medicine* 36, no. 4 (2018): 545–550.
24. Goedecke Maximilian, Florian Kühn, Ioannis Stratos, Robin Vasan, Annette Pertschy, and Ernst Klar. "No Need for Surgery? Patterns and Outcomes of Blunt Abdominal Trauma." *Innovative Surgical Sciences* 4, no. 3 (2019): 100-107.
25. Hayes, Curtis W., William F. Conway, James W. Walsh, Lynn Coppage, and Alfred S. Gervin. "Seat Belt Injuries: Radiologic Findings and Clinical Correlation." *RadioGraphics* 11, no. 1 (1991): 23-36.
26. Hefny, Ashraf F., Fathima T. Kunhivalappil, Kikolay Matev, Norma A. Avila, Masoud O. Bashir, and Fikri M. Abu-Zidan. "Usefulness of Free Intraperitoneal Air Detected by CT Scan in Diagnosing Bowel Perforation in Blunt Trauma: Experience from a Community-Based Hospital. *Injury* 46, no. 1 (2015): 100-104.
27. Hoff, William S., Michelle Holevar, Kimberly K. Nagy, Lisa Patterson, Jeffrey S. Young, Abenamar Arrillaga, Michael P. Najarian, and Carl P. Valenziano. "Practice Management Guidelines for the Evaluation of Blunt Abdominal Trauma: The East Practice Management Guidelines Work Group." *The Journal of Trauma: Injury, Infection, and Critical Care* 53, no. 3 (2002): 602–615.
28. Honarpisheh, Hamid. "A Comprehensive Model for Trauma Research Design." *Archives of Trauma Research* 1, no. 1 (2012): 3–13.
29. Jones, Edward L., Robert T. Stovall, Teresa S. Jones, Denis D. Bensard, Clay C Burlew, Jeffrey L. Johnson, Gregory J. Jurkovich, Carlton C. Barnett, Frederic M. Pieracci, Walter L. Biffl, and Ernest E. Moore. "Intra-Abdominal Injury Following Blunt Trauma Becomes Clinically Apparent within 9 Hours." *Journal Trauma Acute Care Surgery* 76, no. 4 (2014): 1020-1023.
30. Jost, Evan, Derek J. Roberts, Todd Penney, Grant Brunet, Chad G. Ball, and Andrew W. Kirkpatrick. "Accuracy of Clinical, Laboratory, and Computed Tomography Findings for Identifying Hollow Viscus Injury in Blunt Trauma Patients with Unexplained Intraperitoneal Free Fluid without Solid Organ Injury." *The American Journal of Surgery* 213, no. 5 (2017): 874–880.
31. Justin, Viktor, Abe Fingerhut, and Selman Uranues, "Laparoscopy in Blunt Abdominal Trauma: For Whom? When? and Why?," *Current Trauma Reports* 3, no. 1 (2017): pp. 43-50.
32. Lamb, C. M., and J. P. Garner. "Selective Nonoperative Management of Civilian Gunshot Wounds to the Abdomen: A Systematic Review of the Evidence." *Injury* 45, no. 4 (2014): 659–666.
33. Malinoski, Darren J., Madhukar S. Patel, Didem O. Yakar, Donald Green, Faisal Qureshi, Kenji Inaba, Carlos V. Brown, and Ali Salim. "A Diagnostic Delay of 5 Hours Increases the Risk of Death After Blunt Hollow Viscus Injury." *The Journal of Trauma* 69, no. 1 (2010): 84–87.
34. Marek, Ashley, Ryan F. Deisler, John B. Sutherland, Gopal Punjabi, Anne Portillo, Jon Krook, Chad J. Richardson, Rachel M. Nygaard, and Arthur L. Ney. "CT Scan-Detected Pneumoperitoneum: An Unreliable Predictor of Intra-Abdominal Injury in Blunt Trauma." *Injury* 45, no. 1 (2014): 116–121.
35. Masudi, Tahir, Helen C. McMahon, Jennifer L. Scott, and Andrew S. Lockey. "Seat Belt-Related Injuries: A Surgical Perspective." *Journal of Emergencies, Trauma, and Shock* 10, no. 2 (2017): 70–73.
36. McNutt, Michelle K., Naga R. Chinapuvvula, Nicholas M. Beckmann, Elizabeth A. Camp, Matthew J. Pommerening, Rece W. Laney, O Clark West, et al. "Early Surgical Intervention for Blunt Bowel Injury." *Journal of Trauma and Acute Care Surgery* 78, no. 10 (2015): 105-111.

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References

37. McStay, Christopher, Anna Ringwelski, Philip Levy, and Eric Legome. "Hollow Viscus Injury." *The Journal of Emergency Medicine* 37, no. 3 (2009): 293-299.
38. Menegaux, Fabrice, Chriophe Tresallet, Mrylin Gosgnach, Quang Nguyen-Than, Olivier Langeron, and Bruno Riou. "Diagnosis of Bowel and Mesenteric Injuries in Blunt Abdominal Trauma: A Prospective Study." *The American Journal of Emergency Medicine* 24, no. 1 (2006): 19-24.
39. Munshi, Imtiaz A., and William Patton. "A Unique Pattern of Injury Secondary to Seatbelt-Related Blunt Abdominal Trauma." *The Journal of Emergency Medicine 27, no.*2 (2004): 183-185.
40. Ng, Alexander, Richard K. Simons, William C. Torreggiania, Stephen G. Ho, Andrew W. Kirkpatrick, and D. Ross Brown. "Intra-Abdominal Free Fluid without Solid Organ Injury in Blunt Abdominal Trauma: An Indication for Laparotomy." *The Journal of Trauma Injury, Infection, and Critical Care* 52, no. 6 (2002): 1134-1140.
41. Paulus, Elena M., Martin A. Croce, Charles P. Shahan, Ben L. Zarzaur, John P. Sharpe, Amirtha Dileepan, Brandon S. Boyd, and Timothy C. Fabian. "Synergistic Effect of Combined Hollow Viscus Injuries on Intra-Abdominal Abscess Formation." *The American Surgeon 81, no.* 7 (2015): 674-678.
42. Peponis, Thomas, George Kasotakis, Jielin Yu, Reginald Alouidor, Barbara Burkott, Adrian A. Muang, Dirk C. Johnson, et al. "Selective Nonoperative Management of Abdominal Gunshot Wounds from Heresy to Adoption: A Multicenter Study of the Research Consortium of New England Centers for Trauma." *Journal of American College of Surgeons* 224, no 6 (2017): 1036-1045.
43. Rudiman, Reno, Nova Saragih, and Andriana Purnama. "Lactate Clearance: Its Relationship with the Success of Nonoperative Management in Patient with Blunt Abdominal Trauma." *International Surgery Journal* 4, no. 5 (2017): 1738-1742.
44. Saladin, Kenneth S. *Anatomy & Physiology*. 4th ed. New York, Ny: McGraw-Hill, 2007. 697-702.
45. Simon, Leslie, Richard Lopez, and Kevin C. King. Blunt Force Trauma. *StatPearls.* Treasure Island, Fl: StatPearls Publishing, 2021.
46. Sorensen, Victor J., Judy N. Mikhail, and Riyad C. Karmy-Jones. "Is Delayed Laparotomy for Blunt Abdominal Trauma a Valid Quality Improvement Measure in the Era of Nonoperative Management of Abdominal Injuries?" *The Journal of Trauma: Injury, Infection, and Critical Care* 52, no. 3 (2002): 426-433.
47. Tan, Ker-Khan, Jody Zhiyang Liu, Tsung-Shyen Go, Appassamy Vijayan, and Ming-Terk Chiu. "Computed Tomography Has an Important Role in Hollow Viscus and Mesenteric Injuries after Blunt Abdominal Trauma." *Injury* 41, no. 5 (2010): 475-478.
48. Taylor, Gregory M., Jonathan P. Zygowiec, Laurie C. Wallace, Dawn C. Zelenka-Joshowitz, and Angel F. Chudler. "Perforated Small Intestine: A Case of a Delayed Presentation of an Intra-Abdominal Injury in a Pediatric Patient With a Seatbelt Sign." *Clinical Medicine Insights: Pediatrics* 13 (2019).
49. Townsend Jr., Courtney M., R. Daniel Beauchamp, B. Mark Evers, and Kenneth L. Mattox. *Sabiston Textbook of Surgery: The Biological Basis of Modern Surgical Practice.* 20th ed. Philadelphia, Pa: Elsevier Science Health Science, 2016.
50. Vailas, Michail G., Demetrios Moris, Stamatios Orfanos, Chrysovalantis Vergadis, and Alexandros Papalampros. "Seatbelt Sign in a Case of Blunt Abdominal Trauma; What Lies Beneath It? *BMC surgery 15*, no. 1 (2015).
51. Watts, Dorraine D., and Samir M. Fakhry. "Incidence of Hollow Viscus Injury in Blunt Trauma: An Analysis from 275,557 Trauma Admissions from the EAST Multi-Institutional Trial." *The Journal of Trauma: Injury, Infection, and Critical Care* 54, no. 2 (2003): 289-294.
52. Weil, Max H. "Defining Hemodynamic Instability," *Update in Intensive Care and Emergency Medicine*, 2005, pp. 9-17.
53. White, Brian K., Daniel J. Cybulski, Zsolt Stockinger, Daniel Grabo, Avi Benov, Homer Tien, Ashley Humphries, and Stacy A. Shackelford. "Blunt Abdominal Trauma, Splenectomy, and Post-Splenectomy Vaccination." *Joint Trauma System Clinical Practice Guideline,* published 13 May 2020.
54. Williams, Michael D., Dorraine Watts, and Samir Fakhry. "Colon Injury after Blunt Abdominal Trauma: Results of the EAST Multi-Institutional Hollow Viscus Injury Study." *The Journal of Trauma: Injury, Infection, and Critical Care* 55, no. 5 (2003): 906-912.
55. Wotherspoon, Sonya, Kevin Chu, and Anthony F. Brown. "Abdominal Injury and Seat-Belt Sign." *Emergency Medicine Australasia* 13, no. 1 (2001): 61-65.

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Questions?

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Recommendations

	Yes	No
SBP 100-110mmHg 91-99mmHg ≤ 90mmHg	 1 2 3	0
WBC 17-18.99 19.01-20.99 ≥ 21	 1 2 3	0
Abnormal Abdominal Exam	1	0

Retrospective Analysis of Blunt Abdominal Trauma and Seatbelt Sign: The Hollow Viscus Injury Predictor Score (HPS)