

# Curiosity or underdiagnosed? Thoracolumbar spinal column injuries with concomitant trauma of the pancreas

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## Research article

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# Abstract

**Background:** The pancreas is an organ which is at risk of damage as a consequence of thoracolumbar spine injury. However, to our knowledge, no studies have provided any prevalence data to support this assumption. Therefore, the coincidence of pancreatic trauma in patients with spine injury is still unknown. Data from the TraumaRegister DGU® (TR-DGU) was analysed to estimate the prevalence of this correlation and to determine its influence on clinical outcome.

**Methods:** A retrospective investigation of cases documented in the TR-DGU between 2008 and 2017 was performed. We included data of patients admitted to participating European trauma centres who had thoracic or lumbar spine injuries and met the following criteria: i) Injury Severity Score (ISS)  $\geq$  9, ii) blunt trauma, and iii) no early transfer out of hospital. We investigated the coincidence of pancreas injury in patients with at least an Abbreviated Injury Scale (AIS) of 2 of the thoracic or lumbar spine. Therefore, we included all kind of relevant injuries of the thoracolumbar spine.

**Results:** In the group with thoracolumbar injury with concomitant pancreatic injury, the mean age was  $43.1 \pm 18.6$  years, and 68% of these patients were male. The most frequent mechanisms of trauma were car (38%) and motorbike (17%) accidents, as well as high falls (23.8%). The mean Injury Severity Score was  $35.7 \pm 16.0$  points and the in-hospital mortality rate was 17.5%. The overall prevalence of pancreatic injury was 60.7 (0.61%; 95% confidence interval (CI), 0.58–0.65) per 10,000 patients. Patients with severe spinal injuries (AIS  $\geq$  2) were more likely to present with a concomitant pancreatic injury compared to patients with no or only minor spinal injury (AIS 0–1) (Odds ratio (OR) 1.78; 95%CI, 1.57–2.01).

**Conclusions:** Concomitant pancreatic injury in patients with spinal injuries of the thoracolumbar spine is rare. However, patients with more severe spinal injuries were overall more likely (OR 1.78) to present with an accompanying pancreatic injury than those with minor thoracolumbar injuries. Therefore, trauma surgeons treating severely injured patients must be alert not to overlook this rare concomitant injury, because it does not clearly correlate with the severity of spinal injury.

## Background

A flexion-distraction fracture is an unstable injury of the spine (1). The proposed mechanism of injury is a flexion and distraction force on the spine over a fulcrum site (2–4), for example a seat belt in a car accident (3–7), but other common trauma mechanisms include falls (6, 8–10). Usually, flexion-distraction injuries in adults are located at the thoracolumbar junction T11 – L2 (8, 11), and fractures of the thoracolumbar spine are common (8, 9, 12, 13). Due to its biomechanical properties, this region appears to be a weak point of the spine (1, 6), representing the transition from the rigid rib cage to the most flexible lumbar spine (9, 14, 15), making it more vulnerable to traumatic lesions (14). Concomitant intraabdominal injuries are often described in such fractures (3, 5, 8, 16–18). In case of injuries due to seat belts, there is a direct compression of the abdomen, which results in compression of the intraabdominal organs against the vertebral column (19, 20). The pancreas is a retroperitoneal organ that

runs across the spine in the area of the upper lumbar vertebrae. Due to the anatomy of the pancreas, a linkage of these injuries in high velocity trauma of the thoracolumbar spine can be expected (21), even if the pancreas is well protected due to its dorsal location in the abdomen. The retroperitoneal location is also responsible for the poor presence of clinical symptoms (20) so that a pancreatic trauma is difficult to diagnose (19, 22–24). To make matters worse, there is a difficult presentation of pancreatic injury in the computed tomography (CT) scan (25–28), which often leads to a delayed diagnosis. In addition, increases in serum amylase and lipase laboratory parameters can only be observed a few hours after the insult, if at all (27, 29, 30). The typical clinical triad of upper abdominal pain, leucocytosis and elevation of serum amylase levels is rarely pronounced (31). However, early diagnosis of traumatic pancreatic injury is very important because of possible complications with an increase of morbidity and mortality (25, 32–35). An undetected or delayed diagnosis of traumatic pancreatic injury can cause severe retroperitoneal or abdominal inflammation, like pancreatitis (22, 23, 36), or in case of a disruption of the main pancreatic duct, a pseudopancreatic cyst (24, 36). Other complications are infection, abscess, duct stricture, and endocrine/exocrine insufficiency, which are associated with high morbidity and mortality (19, 22, 23, 31, 37). This severely complicates the course of the disease after pancreatic trauma in patients with multiple injuries.

Previously published data on spinal injuries with concomitant pancreatic trauma all refer to smaller case series. However, there is no description of the exact prevalence of this injury in a large trauma collective. The data from the TraumaRegister DGU® (TR-DGU) was analysed to estimate the prevalence of pancreatic trauma in thoracolumbar spinal column injuries and to determine its significance on clinical outcome.

## Methods

### TraumaRegister DGU® (TR-DGU)

The TraumaRegister DGU® of the German Trauma Society (Deutsche Gesellschaft für Unfallchirurgie, DGU) was founded in 1993. The aim of this multi-centre database is a pseudonymised and standardised documentation of severely injured patients.

Data are collected prospectively in four consecutive time phases from the site of the accident until discharge from hospital: A) Pre-hospital phase, B) Emergency room and initial surgery, C) Intensive care unit and D) Discharge. The documentation includes detailed information on demographics, injury pattern, comorbidities, pre- and in-hospital management, course on intensive care unit, relevant laboratory findings including data on transfusion and outcome of each individual. The inclusion criterion is admission to hospital via emergency room with subsequent ICU/ICM care or reach the hospital with vital signs and die before admission to ICU.

The infrastructure for documentation, data management, and data analysis is provided by AUC - Academy for Trauma Surgery (AUC - Akademie der Unfallchirurgie GmbH), a company affiliated to the

German Trauma Society. The scientific leadership is provided by the Committee on Emergency Medicine, Intensive Care and Trauma Management (Sektion NIS) of the German Trauma Society. The participating hospitals submit their data pseudonymised into a central database via a web-based application. Scientific data analysis is approved according to a peer review procedure laid down in the publication guideline of TraumaRegister DGU®.

The participating hospitals are primarily located in Germany (90%), but a rising number of hospitals of other countries contribute data as well (at the moment from Austria, Belgium, China, Finland, Luxembourg, Slovenia, Switzerland, The Netherlands, and the United Arab Emirates). Currently, approx. 33,000 cases from more than 650 hospitals are entered into the database per year.

Participation in TraumaRegister DGU® is voluntary. For hospitals associated with TraumaNetzwerk DGU®, however, the entry of at least a basic data set is obligatory for reasons of quality assurance.

The present study is in line with the publication guidelines of the TraumaRegister DGU® and registered as TR-DGU project ID 2019-014.

## **Inclusion and Exclusion Criteria**

A retrospective study of patients documented in the TR-DGU by a European hospital between 2008 and 2017 was performed. Only cases with blunt trauma and an Injury Severity Score (ISS)  $\geq 9$  were included. Patients who were transferred out to another hospital within 48 hours were excluded in order to prevent from double counting. Patients without or with a minor (AIS severity 1) thoracolumbar spinal column injury served as a control group (flow chart, Figure 1). All types of traumatic pancreatic injuries were included. Patients with all types of relevant thoracolumbar spinal column injuries with an Abbreviated Injury Scale (AIS) severity  $\geq 2$ , were included in the study collective. For descriptive analysis, the frequency of pancreatic injuries in relation to the severity of the spinal column injury, according to the AIS, was performed.

## **Statistical analysis**

We performed a descriptive data analysis to investigate the prevalence of accompanying pancreatic trauma in thoracolumbar injuries. Categorical variables are presented with counts and percentages, and continuous values are shown as mean and standard deviation (SD). We calculated 95% confidence intervals (CI) and odds ratios (OR) where appropriate. The statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) (version 24, IBM Inc., Armonk, NY, U.S.A.).

## **Results**

A total of 44,279 of 179,846 patients had a relevant thoracolumbar spinal column injury (AIS  $\geq 2$ ). The average age of the study collective was  $43.1 \pm 18.6$  years in the group with ( $n = 400$ ) and  $49.9 \pm 20.2$  years in the group without ( $n = 43,879$ ) pancreas injury. Of the patients with pancreas injury, 68.0% were

male. The most common cause of trauma in patients with concomitant pancreas injury were car (38.0%) or motorbike (17%) accidents and high falls (>3 meters; 23.8%). Overall, 63.3% of the accidents with subsequent pancreatic injury occurred in road traffic, in contrast to 48.5% in thoracolumbar injuries without involvement of the pancreas. The injury severity showed up with a mean ISS of  $35.7 \pm 16.0$  in cases with and  $23.8 \pm 12.4$  ( $p < 0.001$ ) in cases without pancreatic injury. Most of the patients with concomitant pancreatic injury had an ISS  $\geq 25$  ( $n = 287$ ; 71.8%) (Table 1). The average hospital stay (32.8 versus 22.1 days) as well as the length of stay (LOS) on an intensive care unit (ICU; 17.5 versus 8.7 days) was longer in patients with pancreatic injury. Additionally, complications such as sepsis (19.4% versus 8.3%) and multi organ failure (MOF; 54.0% versus 25.7%) were more common in the group with pancreatic injury. The in-hospital mortality was almost twice as high in patients with pancreatic injury (17.5% versus 9.7%) (Table 2).

In approximately 28% of cases, patients with thoracolumbar spinal injuries presented with a relevant (AIS 3+) accompanying injury of the head, regardless of the presence of a pancreatic injury. An accompanying limb injury was more common in patients with a pancreatic injury, in contrast to a thoracolumbar spinal injury without a pancreatic trauma (44.8% versus 30.3%).

About three-quarters ( $n = 317$ ; 79.3%) of patients with concomitant pancreatic injury showed up with an AIS of 2 (contusion or minor laceration). The overall prevalence of pancreatic injury was 60.7 (0.61%; 95%CI, 0.57-0.64) per 10,000 patients in all cases (with and without spine injury). In cases with a thoracolumbar spinal injury, the prevalence was 0.90%, or 90 per 10,000 patients. In cases without a spinal injury, the prevalence was 0.51%. Thus, the odds ratio (OR) for a pancreatic injury is 1.78 (95%CI, 1.57-2.01) in patients with a thoracolumbar spinal injury (Table 3). If cases with isolated head injury were excluded from the control group, the prevalence rate would increase to 0.65%, and odds ratio would be 1.39 (95%CI, 1.23-1.58).

Based on the severity of the spinal column injury, there were 317 cases (79.3%) in the group of pancreatic trauma patients with an AIS of 2 points of the thoracolumbar spine, and only 51 cases (12.8%) with an AIS of 3 points. Finally, it appears that especially moderate (AIS 2, OR 1.93; 95%CI 1.68-2.20) and very serious (AIS 5, OR 1.99; 95%CI 1.32-3.00) thoracolumbar spinal injuries are more likely to be associated with an accompanying pancreatic injury than spinal injuries with an AIS of 3 (OR 1.16; 95%CI 0.87-1.54).

## Discussion

To our knowledge, this is the first report investigating the correlation between concomitant pancreatic injuries and severity of trauma to the thoracolumbar spine in a large trauma collective. It can be concluded that concomitant pancreatic injuries are rare, with a prevalence of 0.90% in a group of severely injured patients with trauma of the thoracolumbar spine.

In our collective, middle-aged men in particular presented with an injury to the thoracolumbar spine. Such injuries are also described mainly in men in the literature; however, they were younger on average (8, 9). The average age in our collective is also higher in the group with concomitant pancreatic injury than in

the literature (32). The trauma mechanisms that are mainly presented in our analysis coincide with the results of previous studies (5, 6, 8, 9, 32).

The general occurrence of traumatic pancreatic injury in the polytraumatized patient turned out to be rare, with a ratio of 6/1,000 patients in our study collective. This matches the results of the literature (19, 22, 38). However, patients with moderate to severe spinal injuries more often presented an accompanying pancreatic trauma (OR 1.78). It was shown that these concomitant pancreatic injuries occur primarily in spine injuries with a severity of AIS 2 (n = 317; OR 1.93). In our collective, this severity of injury corresponds to a minor vertebral fracture, the dislocation of a facet joint or injury of the nerve root, without involvement of the spinal cord.

There was a decrease in the cases of pancreatic trauma combined with thoracolumbar spine injuries with a severity of AIS  $\geq 3$ . Although the odds ratio for the occurrence of a pancreatic injury was increased in patients with severe thoracolumbar spinal injuries (AIS 4, OR 1.87; AIS 5, OR 1.99), it should be mentioned that the number of cases was significantly lower (AIS 4, n=8; AIS 5, n=24). Due to the anatomical conditions of the pancreas in the retroperitoneum, a high velocity trauma of the abdomen is necessary to cause a pancreatic trauma (22). This is shown by the fact that patients with pancreatic trauma showed up with more severe injury patterns (mean ISS 35.7) than thoracolumbar injuries without pancreatic trauma (mean ISS 23.8). In the literature, too, patients with traumatic pancreatic injuries were more seriously injured on average (32). In some cases, the main force may be absorbed by the abdomen, so that the spinal injury is less severe than the abdominal; this could be a potential explanation for the decreased probability of concomitant pancreatic trauma between the injury severity groups AIS 2 and AIS 3 (OR 1.93 versus 1.16) in thoracolumbar injuries. This should be examined in future biomechanical studies. The pancreas appears to be at risk of injury due to its location across the thoracolumbar spine and its fixed retroperitoneal location.

Based on our results, there is no direct correlation between the severity of a spinal injury and the occurrence of a concomitant pancreatic trauma. Nevertheless, as mentioned above, there was an accumulation of pancreatic injuries in moderate thoracolumbar injuries. That is why the knowledge of the epidemiology of thoracolumbar spinal injuries and accompanying trauma of surrounding organs is useful and important for assessment, decision making and treatment in patients who have suffered a blunt trauma and are admitted to the emergency room.

Both a pancreatic injury (19, 21, 31, 39) and a thoracolumbar spinal injury can be overlooked clinically. Due to the often delayed or missing diagnosis of a pancreatic injury (24, 25, 32), the reported prevalence may be underestimated in our study as well as in the literature. For this reason, special attention should be paid to the spine and pancreas in the initial diagnostic investigation of a patient who has suffered a blunt abdominal trauma with hyperflexion. A missing diagnosis of a pancreatic injury can lead to complications in the course of treatment (19, 22, 31, 37, 38, 40), as well as long-term consequences like a diabetes (36). This fact was also evident in our study collective with increased complications such as sepsis and MOF in patients with concomitant pancreatic injury. The presence of pancreatic trauma is

associated with high rates of morbidity and mortality (22, 32, 38, 41, 42). In our study collective, the in-hospital mortality with accompanying pancreatic injury was also increased, as well as the length of stay on ICU and the length of time in hospital in general. This is due to the increased occurrence of complications and illustrates the clinical relevance of the simultaneous occurrence of a pancreatic injury. In this context, pancreatic injury does not represent an independent risk factor. The effect of a pancreatic injury (adjusted OR 0.88; 95%CI 0.63-1.25) is mostly represented by the Revised Injury Severity Classification II (RISC II), via the AIS of the most severe and second most severe injury.

Diagnostically, a CT scan (21, 23, 26, 28) and laboratory testing (29, 30) of pancreatic amylase and lipase turn out to be important diagnostic tools. However, both can initially be negative (23, 25, 27, 29). Therefore, it is important to remain alert to a combination of thoracolumbar spine and pancreas injuries in order to repeat examinations if an injury is suspected.

### **Study limitations**

Because of a register evaluation this study has some limitations. It contains only retrospective data that were registered in the TR-DGU. If the diagnosis of a pancreatic injury is missing, it is not recorded in the register. The overall prevalence of a pancreatic trauma can, thus, be underestimated.

Epidemiological data, in particular, were presented in this study. The clinical relevance as well as the influence on the outcome has to be evaluated in future clinical prospective studies.

## **Conclusions**

Concomitant pancreatic trauma in case of thoracolumbar spinal injuries is rare. However, a minor correlation could be seen between patients with a moderate spinal column injury (AIS = 2) compared to mild (AIS 0–1) injuries (OR 1.93). Consequently, in cases of moderate thoracolumbar spinal column injuries, a concomitant injury of the pancreas should be considered in order not to overlook the injury.

## **Declarations**

### Ethics approval and consent to participate

This study has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

### Consent for publication

'Not applicable' for that section

### Availability of data and materials

The data that support the findings of this study are available from (AUC GmbH, TraumaRegister DGU®) but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of (AUC GmbH, TraumaRegister DGU®).

### Competing interests

The authors report no conflict of interest concerning the materials or methods referred in this study nor the findings specified in this article. The authors state that this work has not been previously published in whole or in part or submitted elsewhere for review.

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### Authors' contributions

JH wrote the original manuscript, analysed and interpreted the data and performed a profound literature search. SH and KJ analysed and interpreted the data and critically revised the manuscript. KS supervised the project, developed the research idea, analysed and interpreted the data and critically revised the manuscript. RL performed statistical analyses. TB, HT, TDP and HCP interpreted data and critically revised the manuscript. All authors read and approved the final manuscript.

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## **Abbreviations**

- AIS = Abbreviated Injury Scale
- CI = Confidence interval
- CT = Computed tomography
- ICU = Intensive care unit
- ISS = Injury Severity Score
- LOS = Length of stay

- m = metre
- MOF = Multi organ failure
- n = number
- OR = Odds ratio
- RISC II = Revised Injury Severity Classification, version II
- SD = Standard deviation
- SPSS = Statistical Package for the Social Sciences
- TR-DGU = TraumaRegister DGU®

## References

1. Kim BG, Dan JM, Shin DE. Treatment of thoracolumbar fracture. *Asian Spine J.* 2015;9(1):133–46.
2. Chance GQ. Note on a type of flexion fracture of the spine. *Br J Radiol.* 1948;21(249):452.
3. Gertzbein SD, Court-Brown CM. Flexion-distraction injuries of the lumbar spine. Mechanisms of injury and classification. *Clin Orthop Relat Res.* 1988;227:52–60.
4. Smith WS, Kaufer H. Patterns and mechanisms of lumbar injuries associated with lap seat belts. *J Bone Joint Surg Am.* 1969;51(2):239–54.
5. Anderson PA, Rivara FP, Maier RV, Drake C. The epidemiology of seatbelt-associated injuries. *The Journal of trauma.* 1991;31(1):60–7.
6. Holmes JF, Miller PQ, Panacek EA, Lin S, Horne NS, Mower WR. Epidemiology of thoracolumbar spine injury in blunt trauma. *Acad Emerg Med.* 2001;8(9):866–72.
7. Savitsky E, Votey S. Emergency department approach to acute thoracolumbar spine injury. *J Emerg Med.* 1997;15(1):49–60.
8. Bernstein MP, Mirvis SE, Shanmuganathan K. Chance-type fractures of the thoracolumbar spine: imaging analysis in 53 patients. *AJR Am J Roentgenol.* 2006;187(4):859–68.
9. Hsu JM, Joseph T, Ellis AM. Thoracolumbar fracture in blunt trauma patients: guidelines for diagnosis and imaging. *Injury.* 2003;34(6):426–33.
10. Wang GL, Yang HL, Cai X, Shi JH, Tang TS. [Diagnosis and surgical treatment of thoracolumbar vertebral Chance fractures caused by a fall]. *Zhonghua Wai Ke Za Zhi.* 2008;46(10):741–4.
11. Ragel BT, Allred CD, Brevard S, Davis RT, Frank EH. Fractures of the thoracolumbar spine sustained by soldiers in vehicles attacked by improvised explosive devices. *Spine (Phila Pa 1976).* 2009;34(22):2400–5.
12. Hu R, Mustard CA, Burns C. Epidemiology of incident spinal fracture in a complete population. *Spine (Phila Pa 1976).* 1996;21(4):492–9.
13. DeWald RL. Burst fractures of the thoracic and lumbar spine. *Clinical orthopaedics and related research.* 1984(189):150–61.

14. Schroeder GD, Kepler CK, Koerner JD, Chapman JR, Bellabarba C, Oner FC, et al. Is there a regional difference in morphology interpretation of A3 and A4 fractures among different cultures? *J Neurosurg Spine*. 2016;24(2):332–9.
15. Denis F. The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. *Spine (Phila Pa 1976)*. 1983;8(8):817–31.
16. Karargyris O, Morassi L, Zafeiris C, Evangelopoulos D, Pneumaticos S. The unusual chance fracture: case report & literature review. *Open Orthop J*. 2013;7:301–3.
17. LeGay DA, Petrie DP, Alexander DI. Flexion-distraction injuries of the lumbar spine and associated abdominal trauma. *The Journal of trauma*. 1990;30(4):436–44.
18. Richards D, Carhart M, Raasch C, Pierce J, Steffey D, Ostarello A. Incidence of thoracic and lumbar spine injuries for restrained occupants in frontal collisions. *Annu Proc Assoc Adv Automot Med*. 2006;50:125–39.
19. Debi U, Kaur R, Prasad KK, Sinha SK, Sinha A, Singh K. Pancreatic trauma: a concise review. *World J Gastroenterol*. 2013;19(47):9003–11.
20. Hasanovic J, Agic M, Rifatbegovic Z, Mehmedovic Z, Jakubovic-Cickusic A. Pancreatic injury in blunt abdominal trauma. *Med Arch*. 2015;69(2):130–2.
21. Coppola V, Vallone G, Verrengia D, Di Filippo G, Alfinito M, Coppola M, et al. [Pancreatic fractures: the role of CT and the indications for endoscopic retrograde pancreatography]. *Radiol Med*. 1997;94(4):335–40.
22. Akhrass R, Yaffe MB, Brandt CP, Reigle M, Fallon WF Jr, Malangoni MA. Pancreatic trauma: a ten-year multi-institutional experience. *Am Surg*. 1997;63(7):598–604.
23. Dave S, London S. Pancreatic Trauma. *StatPearls*. Treasure Island (FL)2019.
24. Bradley EL 3rd, Young PR Jr, Chang MC, Allen JE, Baker CC, Meredith W, et al. Diagnosis and initial management of blunt pancreatic trauma: guidelines from a multiinstitutional review. *Ann Surg*. 1998;227(6):861–9.
25. Cirillo RL Jr, Koniaris LG. Detecting blunt pancreatic injuries. *J Gastrointest Surg*. 2002;6(4):587–98.
26. Gupta A, Stuhlfaut JW, Fleming KW, Lucey BC, Soto JA. Blunt trauma of the pancreas and biliary tract: a multimodality imaging approach to diagnosis. *Radiographics*. 2004;24(5):1381–95.
27. Linsenmaier U, Wirth S, Reiser M, Korner M. Diagnosis and classification of pancreatic and duodenal injuries in emergency radiology. *Radiographics*. 2008;28(6):1591–602.
28. Venkatesh SK, Wan JM. CT of blunt pancreatic trauma: a pictorial essay. *Eur J Radiol*. 2008;67(2):311–20.
29. Mahajan A, Kadavigere R, Sripathi S, Rodrigues GS, Rao VR, Koteswar P. Utility of serum pancreatic enzyme levels in diagnosing blunt trauma to the pancreas: a prospective study with systematic review. *Injury*. 2014;45(9):1384–93.
30. Singh RP, Mahajan A, Selhi JS, Garg N, Chahal H, Bajwa M. Management and Outcome of Patients with Pancreatic Trauma. *Niger J Surg*. 2017;23(1):11–4.

31. Wong YC, Wang LJ, Lin BC, Chen CJ, Lim KE, Chen RJ. CT grading of blunt pancreatic injuries: prediction of ductal disruption and surgical correlation. *J Comput Assist Tomogr.* 1997;21(2):246–50.
32. Kao LS, Bulger EM, Parks DL, Byrd GF, Jurkovich GJ. Predictors of morbidity after traumatic pancreatic injury. *The Journal of trauma.* 2003;55(5):898–905.
33. Biffl WL, Moore EE, Croce M, Davis JW, Coimbra R, Karmy-Jones R, et al. Western Trauma Association critical decisions in trauma: management of pancreatic injuries. *J Trauma Acute Care Surg.* 2013;75(6):941–6.
34. Lin BC, Chen RJ, Fang JF, Hsu YP, Kao YC, Kao JL. Management of blunt major pancreatic injury. *The Journal of trauma.* 2004;56(4):774–8.
35. Wolf A, Bernhardt J, Patrzyk M, Heidecke CD. The value of endoscopic diagnosis and the treatment of pancreas injuries following blunt abdominal trauma. *Surg Endosc.* 2005;19(5):665–9.
36. Morita T, Takasu O, Sakamoto T, Mori S, Nakamura A, Nabeta M, et al. Long-Term Outcomes of Pancreatic Function Following Pancreatic Trauma. *Kurume Med J.* 2017;63(3.4):53–60.
37. Fischer JH, Carpenter KD, O'Keefe GE. CT diagnosis of an isolated blunt pancreatic injury. *AJR Am J Roentgenol.* 1996;167(5):1152.
38. Kuza CM, Hirji SA, Englum BR, Ganapathi AM, Speicher PJ, Scarborough JE. Pancreatic Injuries in Abdominal Trauma in US Adults: Analysis of the National Trauma Data Bank on Management, Outcomes, and Predictors of Mortality. *Scand J Surg.* 2019:1457496919851608.
39. Buccimazza I, Thomson SR, Anderson F, Naidoo NM, Clarke DL. Isolated main pancreatic duct injuries spectrum and management. *American journal of surgery.* 2006;191(4):448–52.
40. Ho VP, Patel NJ, Bokhari F, Madbak FG, Hambley JE, Yon JR, et al. Management of adult pancreatic injuries: A practice management guideline from the Eastern Association for the Surgery of Trauma. *J Trauma Acute Care Surg.* 2017;82(1):185–99.
41. Subramanian A, Dente CJ, Feliciano DV. The management of pancreatic trauma in the modern era. *Surg Clin North Am.* 2007;87(6):1515-32, x.
42. Girard E, Abba J, Arvieux C, Trilling B, Sage PY, Mougin N, et al. Management of pancreatic trauma. *J Visc Surg.* 2016;153(4):259–68.

## Tables

| <b>Table 1</b> Demographic- and trauma-related data |  |                                   |
|---|--|-----------------------------------|
|   | Without pancreatic injury<br>n = 43,879        | With pancreatic injury<br>n = 400 |
| Mean age (years)                                    | 49.9 (20.2)                                    | 43.1 (18.6)                       |
| Gender, male (%)                                    | 71.8   | 68.0                              |
| Severity of thoracolumbar trauma                    |  |                                   |
| AIS 2   | 32,103 (73.2%)                                 | 317 (79.3%)                       |
| AIS 3   | 8,597 (19.6%)                                  | 51 (12.8%)                        |
| AIS 4   | 832 (1.9%)                                     | 8 (2.0%)                          |
| AIS 5   | 2,347 (5.3%)                                   | 24 (6.0%)                         |
| ISS   |  |                                   |
| Mean  | 23.8   | 35.7                              |
| SD  | 12.4   | 16.0                              |
| ISS $\geq$ 25, n (%)                                | 16,525 (37.7%)                                 | 287 (71.8%)                       |
| Injury mechanism                                    |  |                                   |
| traffic - car                                       | 23.8%  | 38.0%                             |
| traffic - motorbike                                 | 13.5%  | 17.0%                             |
| traffic - bicycle                                   | 5.8%   | 3.5%                              |
| traffic - pedestrian                                | 5.4%   | 4.8%                              |
| high fall (>3m)                                     | 30.3%  | 23.8%                             |
| low fall  | 14.2%  | 3.8%                              |
| Relevant head injury (AIS 3+)                       | 28.6%  | 28.5%                             |
| Relevant thoracic trauma (AIS 3+)                   | 56.1%  | 80.8%                             |
| Relevant injury of the extremities                  | 30.3%  | 44.8%                             |
| Polytrauma (Berlin definition)                      | n = number; m = metre; SD = standard deviation | 55.5%                             |

| <b>Table 2</b> Outcome parameter |   |                                   |
|----------------------------------|---|-----------------------------------|
|                                  | Without pancreatic injury<br>n = 43,879 | With pancreatic injury<br>n = 400 |
| Length of stay - LOS (days)      | 22.1 (21.7), median 16                  | 32.8 (30.2), median 26            |
| ICU LOS (days)                   | 8.7 (12.4), median 4                    | 17.5 (18.4), median 9             |
| In-Hospital mortality, n (%)     | 4,277 (9.7%)                            | 70 (17.5%)                        |
| Sepsis*, n (%)                   | 1,878 (8.3%)                            | 40 (19.4%)                        |
| MOF*, n (%)                      | 5,949 (25.7%)                           | 114 (54.0%)                       |

ICU = intensive care unit; MOF = multi organ failure; n = number

\*available only for patients with standard documentation

| <b>Table 3</b> Risk of injured pancreas depending on severity of thoracolumbar injury |             |                    |
|---|-------------|--------------------|
| AIS thoracolumbar   | OR          | CI 95%             |
| ≤1  | (reference) |                    |
| 2   | 1.93        | 1.68 – 2.20        |
| 3   | 1.16        | 0.87 – 1.54        |
| 4   | 1.87        | 0.93 – 3.78        |
| 5   | 1.99        | 1.32 – 3.00        |
| <b>2 - 5</b>  | <b>1.78</b> | <b>1.57 – 2.01</b> |

OR = odds ratio; CI = confidence interval

## Figures

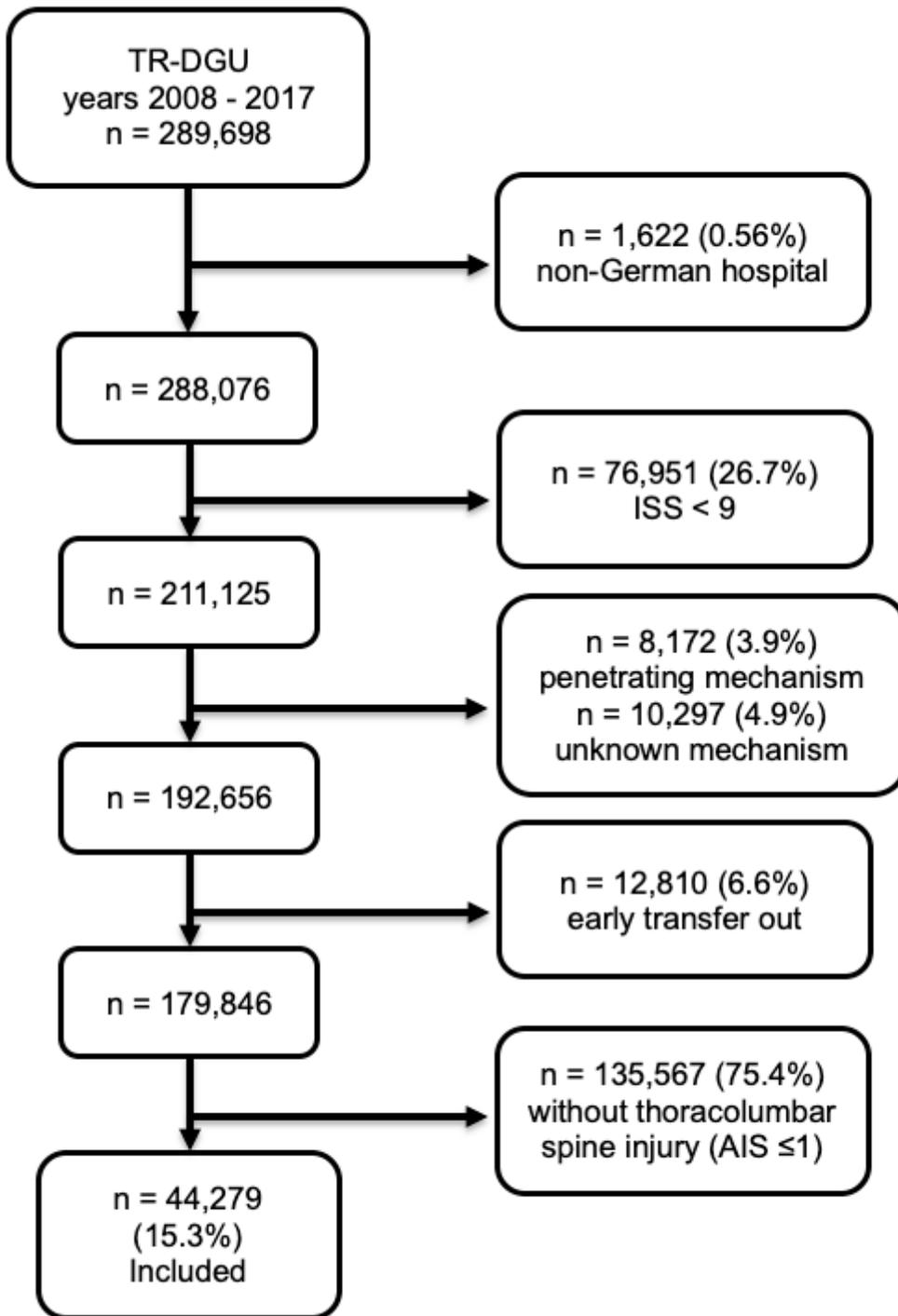


Figure 1

Figure 1: Patient inclusion flowchart n = number