Pre-hospital Management in Trauma Patients: a Comparison Between Austria and Germany

Amelie Kanovsky (amelie.kanovsky@pmu.ac.at)
Paracelsus Medical Private University: Paracelsus Medizinische Privatuniversitat
https://orcid.org/0000-0002-8352-7371
Christian Deininger
Paracelsus Medizinische Privatuniversitat
Florian Wichlas
University of Salzburg: Universitat Salzburg
Andreas Traweger
Paracelsus Medical University Salzburg: Paracelsus Medizinische Privatuniversitat
Rolf Lefering
Universität Witten/Herdecke: Universitat Witten/Herdecke
Ernst J. Mueller
Landeskrankenhaus Klagenfurt: Klinikum Klagenfurt am Worthersee

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Abstract

Objectives

To compare the pre-hospital treatment and intervention regimen for major trauma patients with comparable injury patterns between Austria (AUT) and Germany (GER).

Patients and Methods

This analysis is based on data retrieved from the TraumaRegister DGU®. Data included severely injured trauma patients with an Injury Severity Score (ISS) ≥ 16, an age ≥ 16, and who were primary admitted to an Austrian (n=4.186) or German (n=41.670) Level I Trauma Center from 2008 to 2017. Endpoints included pre-hospital times and interventions performed until final hospital admission. The analyzed data include patients' demographics, mode of transportation, pre-hospital time management, hemodynamic stability, and various pre-hospital interventions.

Results

The cumulative time for transportation from the site of accident to the hospital did not significantly differ between the countries (62 min. in AUT, 65 min. in GER). Overall, 53% of all trauma patients in AUT were transported to the hospital with a helicopter compared to 37% in GER (P<0.001). The rate of intubation - 48% in both countries, the number of chest tubes placed (5.7% GER, 4.9% AUT), and the frequency of administered catecholamines (13.4% GER, 12.3% AUT) was comparable (Φ=0.00). Hemodynamic instability upon arrival in the TC was higher in AUT, (20.6% vs. 14.7% in GER; P<0.001). A median of 500mL of fluid was administered in AUT, whereas in GER 1000mL were infused (P<0.001). Patient demographics did not reveal a relationship (Φ=0.00) and the majority of patients sustained a blunt trauma (96%).

Conclusion

A significant higher number of Helicopter EMS transports (HEMS) were carried out in AUT. This can be explained by the overall lack of a unified transport algorithm. The authors suggest implementing an international guideline to explicitly use the HEMS system for trauma patients only a) for the rescue/care of people who have had an accident or are in life-threatening situations, b) for the transport of emergency patients with ISS>16, c) for transport of rescue personnel to hard-to-reach regions or, d) for the transport of medicinal products. Further, the amount of administered fluid in the pre-clinical setting should follow the concept of permissive hypotension/ hypotensive resuscitation, however the data are still inconclusive and mandate further research.

1. Introduction

Trauma registry comparisons are a feasible method for quality control, including the identification and detailed analysis of subgroups between countries [1]. They further allow to improve the quality of care

[2–4], although international comparisons between trauma systems are still rare and lack a unified approach. Associating the pre-hospital, as well as the institutional performances between countries, underlies a careful patient-selection with adequate adjustments in case-mix and functional prediction models [5].

This study compares pre-hospital interventions performed in Austria (AUT) and Germany (GER) based on entries in the TraumaRegister DGU® (TR-DGU), focusing on patients with multiple injuries. The advantage of this study is availability of data entries from AUT and GER into the common TR-DGU database, hence allowing for a direct data comparison.

Austria and Germany share a large border with similar emergency medical services (EMS) but alter in their geographic environments. Both countries rely on two different transportation systems in the care for trauma patients: Helicopter or ambulance transport with a physician. To the best of our knowledge, no prior evaluation comparing the Austrian and German pre-hospital trauma system has been conducted. Consequently, a comparative approach was chosen for this study aiming to determine differences in the pre-hospital management and to optimize treatment regimens.

Specifically, this study addressed four questions:

1. Is there a difference in the pre-hospital time management in Austria *versus* Germany?
2. Does the mode of transportation to Level I Trauma Centers (TCs) differ between the countries?
3. Are there differences in the pre-hospital interventions performed in each country?
4. Are there differences in patient demographics between Germany and Austria?

2. Methods

2.1 TraumaRegister DGU®

The TraumaRegister DGU® is one of the largest registers of its kind worldwide and was founded in 1993. The aim of this multi-center database is a pseudonymized and standardized documentation of severely injured patients. Data are collected prospectively in four consecutive time phases from the site of the accident until dis- charge from hospital: A) Pre-hospital phase, B) Emergency room and initial surgery, C) Intensive care unit and D) Discharge. 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 patient.

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 pseudonymized into a central database via a web-based application.

Scientific data ana- lysis is approved according to a peer review procedure defined in the publication guideline of the TR-DGU.

The participating hospitals are primarily located in Germany (90%), but an increasing number of hospitals of other countries also contribute (i.e., Austria, Belgium, China, Finland, Luxembourg, Slovenia, Switzerland, The Netherlands, and the United Arab Emirates). Currently, approximately 30,000 cases per year from more than 650 hospitals are being entered into the database.

Participation in TR-DGU is voluntary. For hospitals associated with TR-DGU however, the entry of at least a basic data set is obligatory for reasons of quality assurance. Based on this data, statements about quality of care can be defined and medical treatment methods examined for their effectiveness.

The present study is in line with the publication guidelines of the TraumaRegister DGU® and registered as TR-DGU project ID 2017-031.

2.2 Patients and Data acquisitions

This study is a retrospective analysis of trauma patients in AUT and GER, focusing on pre-hospital time, mode of transportation and interventions performed by physicians in the pre-hospital setting. All data were retrieved from the TraumaRegister DGU® (TR-DGU). Patient data from the TR-DGU from 2008–2017 were analyzed. Data before 2008 was excluded due to the limited number of participating hospitals in Austria. Twenty-nine trauma centers (TCs) from Austria and nearly all German TCs (90%) contributed data to the TR-DGU.

Inclusion criteria: primary admission (i.e., no transfers in / no early transfer out < 48h), age ≥ 16 years, and Injury Severity Score (ISS) ≥ 16 points. The analysis was restricted to Austrian and German Level I trauma centers reporting to the TNW.

Austrian and German patient's data comparison was based on to the following criteria:

- Age group (stratified: 16–59; 60–69; 70–79; ≥ 80 years)
- Sex (male/female)
- Identical pattern of relevant injuries (AIS ≥ 3) in four anatomic body regions (head, thorax, abdomen, extremities)
- Mechanism of trauma (blunt/penetrating)
- Traumatic brain injury (TBI)
- Pre-trauma ASA score
- Traffic accident (yes/no)
- Hemodynamic instability on-scene (i.e., initial systolic blood pressure (BP) ≤ 90 mmHg)
- Mode of transportation: Ambulance with physician, Helicopter with physician.

The main focus of this study were pre-hospital times and interventions performed until the patient's care was taken over by the hospital's emergency room.

2.3 Statistical analysis

All parameters form the TR-DGU, including data from Austrian and German TCs were obtained from the same database. All comparisons are based on actual entries and no imputations for patients with missing data were performed.

The TR-DGU uses the AIS 2005/ Update 2008 version of the Abbreviated Injury Scale (AIS) in a reduced version with 450 codes and online help systems for coding. Statistical analysis was conducted using SPSS (Statistical Package for the Social Sciences; version 24, IBM Inc., Armonk, NY, USA) and GraphPad Prism 9.0.0 (San Diego, CA, USA).

Categorical data are presented as percentages. Median and interquartile range (IQR) are shown for skewed data and mean with standard deviation (SD) otherwise. The level of statistical significance was thus set at $P < 0.01$ (Mann-Whitney-U-Test, Qui-Squared-Test). For the measure of association between dichotomous variables, the phi coefficient (Φ) was used to interpret the strength of relationship (-1: perfect negative relationship, 0: no relationship, 1: perfect positive relationship).

3. Results

3.1 Pre-hospital time management

During the observed study period, inclusion criteria were met by 4.186 Austrian (AUT) and 41.670 German (GER) patients who represent the total study population (Fig. 1).

The overall required time for transport of patients from the accident site to the hospital did not differ significantly between Austria and Germany ($P > 0.01$) with a median of 62 minutes and an interquartile range (IQR) of 48–80 minutes *versus* 65 minutes and IQR of 50–85 minutes; a difference of 3 minutes respectively. The median on-scene time, indicating the amount of time it took the EMS team on the site of accident, was less in Austria, 25 minutes *versus* 28 minutes in Germany ($P > 0.01$). The transport time to the TC was 16 minutes in Austria and 17 minutes in Germany (Table 1). All transport times did not significantly differ between both countries ($P > 0.01$).

3.2 Mode of transportation

Transport to level I TCs was carried out with or without a physician. Overall, 95.1% of transports, HEMS (Helicopter transport) and EMS (Ambulance transport), were attended by a physician in Austria, which is almost equivalent to physician-accompanied transports in Germany, 95.9% ($P = 0.011$).

An obvious difference can be observed in the mode of transport. In Austria, 53.4% of trauma patients were transported to the emergency room via helicopter-based EMS compared to 36.6% in Germany ($P <$

0.001). In 46.6% of cases in Austria, patients were transported to the hospital by ground EMS compared to 63.4% in Germany (Fig. 2).

3.3 Pre-hospital interventions

Intubation in the pre-hospital setting was carried out at equivalent rates in both countries, 48.0% (Φ = 0.00). The proportion of chest tubes placed in Germany was 5.7% compared to 4.9% in Austria (Φ = 0.01). Catecholamines were administered to 12.3% of patients in Austria *versus* 13.4% in Germany (Φ = 0.01). A larger difference among the countries can be observed in the amount of sedation/analgesia received. A sedation was administered to 80.0% of patients in Austria and to 71.8% in Germany (Φ = 0.01). A further distinction applies to the perceived hemodynamic stability on accident site: A systolic blood pressure (BP) ≤ 90 mmHg was observed in 17.9% of Austrian patients and in 15.9% of Germans (Φ = 0.02). At the time upon arrival at the TC, 20.6% of Austrian patients were hemodynamically unstable with a systolic BP ≤ 90mmHg *versus* 14.7% in Germany (Φ = 0.05)(Fig. 3). Overall, no relationship between the above-mentioned pre-hospital interventions can be observed between the countries.

A significant difference applies to the directed pre-clinical fluid management: A median of 500mL (IQR: 500-1000mL) of fluid was administered to trauma patients in Austria, compared to a median of 1000ml (IQR: 500-1500mL) in Germany ($P < 0.001$). Upon arrival in the Emergency Department (ED), patients received 1000mL of fluid in Austria (IQR: 500–2000) and Germany (IQR: 500–1500) (Table 2).

3.4 Patients demographics

A blunt trauma was sustained by 96.0% of the entire study population with no difference between the two sub-populations. According to the mechanism of injury, Germany reported a higher rate of traffic accidents involving cars, motorcycles and bicycles. Patient's age did not differ between Germany, 51.3 ± 20.9 years with a mean ISS of 28.0 ± 11.9 points, and Austria, mean age: 50.1 ± 20.3 years, mean ISS: 27.9 ± 11.2 points. The observed American Society of Anesthesiologist (ASA) score 3–4 (http://www.asahq.org), referring to patients with a severe disease, was 16.8% in Germany *versus* 11.9% in Austria. This reflects a 4.9% difference, whereas the prevalence of relevant injuries within the four main body regions (AIS ≥ 3) did not differ between them. For all other parameters analyzed the frequencies were comparable between Austria and Germany and overall, the phi (Φ) coefficient revealed no relationship among the various demographic data (Table 3).

4. Discussion

Our analysis reveals that the pre-hospital management of severe trauma patients is rather similar between Austria and Germany. The observed results, based on registry data, include the pre-hospital management of patients.

The median overall time of transport and time on-scene of the EMS were 3 minutes shorter in Austria. The effect of this difference could be attributed to the mode of transportation (53.4% helicopter transport in Austria *versus* 36.6% in Germany). More than half (53.4%) of all Austrian trauma patients were

transported to a TC with a helicopter, compared to 36.6% in Germany ($P < 0.001$). EMS in Austria are profoundly influenced by its geographic alignment and population shifts during peak tourism seasons (Summer and Winter). Fifty percent of Austria's population lives in small towns or villages scattered all over the country, thereby creating a rural/urban split (50:50). This results in the necessity for adjustments in EMS strategies based on individual country sides. In rural areas, transport times are much longer as distances to medical facilities can be more than 60 km. Therefore, physician-staffed helicopters are predominately used in rural areas, especially in alpine regions where the exclusive usage of ground transportation is difficult or even impossible [8]. Currently, there are 38 helicopter EMS (HEMS) distributed throughout Austria and cover an area of 84.000 square kilometers (1:2211 square kilometers) and 89 in Germany, covering 356.000 square kilometers (1:4000 square kilometers) [9]. In addition, all of the Western, as well as most of the Southern and Central parts of Austria are covered by the Alps where some mountains reach altitudes of up to 3800 meters, relying therefore on a physician-based HEMS [8]. Another reason that might explain the high percentage of helicopter usage in Austria is the increase in the number of trauma patients due to tourism. According to http://www.austria.info, in 2018, 149 million overnight stays by tourists from all over the world were accounted for.

Nevertheless, the potentially beneficial effects of HEMS on patients' outcomes and cost efficiency are still controversially discussed [23]. In summary, trauma patients benefit from HEMS rescue with in-hospital survival as a main outcome parameter. Analyzing different subgroups, older patients, low-energy trauma, and minor injury severity had the most pronounced survival benefit when rescued by HEMS [24]. However, according to the Austrian (OEAMTC) and German (ADAC) Automobile Club, overall, 17.281 and 53.967 HEMS transports to the ED respectively have been carried out in 2019. This correlates to 1.942 HEMS transports per 1 million inhabitants in Austria and 650 transports per 1 million in Germany. The large difference in helicopter transports can further be explained by the overall lack of a regional/national unified algorithm of indications/guidelines for transport. We suggest to explicitly use the HEMS system for trauma patients only a) for the rescue/care of people who have had an accident or are in life-threatening situations, b) for the transport of emergency patients with ISS > 16, c) for transport of rescue or recovery personnel to hard-to-reach regions or, d) for the transport of medicinal products, especially blood products, organ transplants or medical devices. In summary, the usage of the HEMS system in Austria compared to Germany seems too high and should be reevaluated in terms of its on-scene relevance.

Further, this study demonstrates a discrepancy in the pre-hospital fluid administration. A significant difference between the countries was observed for the amount of fluid administered on scene, a median of 500 mL in Austria *versus* 1000 mL in Germany. This may be due to differences in fluid administration habits, as it can be seen in Switzerland [25] and in the Dutch [6] population as well, where 30% less fluid in the pre-hospital setting is being administered when compared to Germany. Kudo et al. elaborate on the importance on achieving a balance between organ perfusion and hemostasis which is critical for optimal fluid resuscitation in trauma patients. "Permissive hypotension" refers to managing trauma patients by restricting the amount of resuscitation fluid and maintaining blood pressure in the lower-than-normal range if there is continuing bleeding during the acute period of injury. However, no study has investigated

which subjects would benefit most from this approach, when considering factors such as age, injury mechanism, setting, or the presence or absence of hypotension [26]. The influence of these approaches on coagulation has not been sufficiently examined, even in animal studies and the overall effectiveness of permissive hypotension/ hypotensive resuscitation is still inconclusive and mandates further research [10–12, 21].

There is no evidence on the required volume threshold for trauma patients [13]. Driessen et al. state that the mean Base Excess (BE) at the time of admission to the ED might indicate a better tissue perfusion despite low BP [14]. In Austria, 20.6% compared to 14.7% of Germans arrived at the TC in a hemodynamically unstable condition, associating with a systolic BP of ≤ 90mmHg. The administration of catecholamines recruits unstressed blood volumes and influences the maintenance of blood pressure [15]. This might be a possible explanation of why the observed hemodynamic instability of Austrian patients arriving at the TC was higher as well as the reduced amount of fluid administered on scene. It can further be excluded that the administration of Tranexamic Acid (TXA) is responsible for the difference in systolic BP upon arrival in the TC, as it was equivalent in both countries. Overall, no algorithm on the exact and correct amount of fluid volume in the pre-clinical setting can be recommended by the authors as it is a dependent variable of age, anticoagulation, blood loss and observed injury pattern.

The mechanism of injury as well as various demographic characteristics do not show a relationship amongst individual variables between both countries and were similar to those found in other studies conducted with the TR-DGU [4,6,7,20]. In General, results should primarily be interpreted in terms of their clinical relevance because the large sample size included in this study likely yields a formal significance even in case of minor differences. Although, a notable variation can be observed by combining geriatric age groups (≥ 70 years) of transported patients within one country. It can be emphasized that more severely injured geriatric patients were transported to TCs in Germany compared to Austria. This further correlates with a greater observed ASA score [16, 17] in Germany as patients age increases. Spering et al. suggest that the number of patients with pre-existing medical conditions, classified according to ASA ≥ 3, increase with accumulative age. Hence, as the age of injured patients rises, so does the cumulative percentage of ASA 3–4 [22]. Overall, a larger number of geriatric patients in Germany have been included in this retrospective data analysis, correlating with a higher observed ASA score (Class 3–4). This classification score includes patients with moderate to severe systemic disease and functional limitations up to a severe systemic disease, which is a constant threat to life [18].

5. Limitations

This retrospective study was conducted using data from a large registry but does not include data from all Austrian TCs. Therefore, the completeness of the submitted data resulted in limitations. Further, the verification of entered data correctness, according to the TR-DGU, was performed only in a small sample of cases. The reported differences in the results could be due to statistical random findings (type I and II error), differences in care and various treatment protocols. Despite the limitations of trauma registries, it serves as a means for quality control and helps to assist in optimizing treatment protocols.

6. Conclusion

There was no meaningful difference between Austria and Germany based on basic demographic characteristics. The on-scene time of EMS arrival was 3 minutes shorter in Austria probably due to the predominant usage of HEMS. Although geographic alterations and tourism might help explain the significant higher number of helicopter transports in Austria, the authors suggest implementing an international guideline to explicitly use the HEMS system for specific indications. Overall, the amount of administered fluid in the pre-clinical setting should follow the concept of permissive hypotension/ hypotensive resuscitation especially in younger patients but is still inconclusive and mandates further research. Further, quality control and registry comparisons should be a fundamental part of trauma patient treatment in hospital organizations.

7. Abbreviations

TR-DGU: TraumaRegister DGU®

AUT: Austria

GER: Germany

EMS: Emergency Medical Services

HEMS: Helicopter Emergency Medical Services

TC: Trauma Center

TXA: Tranexamic Acid

8. Declarations

Ethics approval and consent to participate: The present study is in line with the publication guidelines of the TraumaRegister DGU® and registered as TR-DGU project ID 2017-031.

Consent for publication: Not applicable.

Availability of data and materials: The data that support the findings of this study are available from 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 Rolf Lefering.

Competing interests: Amelie Kanovsky, Christian Deininger, Florian Wichlas, Andreas Traweger, and Ernst J. Mueller have no competing interests.

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Authors' contributions:

CD contributed to the design, data interpretation, drafted the work, approved the submitted version.

FW drafted and substantially revised the work, contributed to the design, approved the submitted version.

RL completed the data analysis, drafted the work, interpreted the data, contributed to the entire concept and design of the work, approved the submitted version.

AT helped with the statistical analysis, drafted the work, contributed to the entire concept and design of the work, approved the submitted version.

EM contributed to the entire concept and design of the work, data acquisition and analysis, drafted and revised the work, approved the submitted version.

AK contributed to the entire concept and design of the work, data acquisition and analysis, drafted and revised the work, approved the submitted version.

CD, FW, RL, AT, EM agree both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

AK (corresponding author) ensures that original data figures/materials upon which the submission is based, follows best practice in the field and are retrievable for reanalysis. AK confirms that data/figures/materials accurately reflect the original and foresees and minimizes obstacles to the sharing of data/materials described in the work. AK ensures that the entire author group is fully aware of and in compliance with best practices in the discipline of publication.

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Tables

Table 1. Pre-hospital time management between Austria and Germany.

	Austria	Germany
Overall time from site of accident to TC (min)		
n	2.954	30.684
Median [IQR]	62 [48-80]	65 [50-85]
P-Value	>0.01	>0.01
On-scene time (min)		
n	2.546	23.886
Median [IQR]	25 [17-35]	28 [19-40]
P-Value	>0.01	>0.01
Transport time to TC (min)		
n	2.613	25.986
Median [IQR]	16 [11-23]	17 [11-24]
P-Value	>0.01	>0.01

Table 2. Differences in fluid volumes administered between Austria and Germany.

	Austria	Germany
Pre-clinical Volume administration (mL)		
n	3.529	37.759
Median [IQR]	500 [500-1000]	1000 [500-1500]
P-Value	<0.001	<0.001
Volume administration in the TC upon arrival (mL)		
n	3.321	35.149
Median [IQR]	1000 [500-2000]	1000 [500-1500]
P-Value	>0.01	>0.01
No pre-clinical Volume administration (mL)		
n	332	2.522
%	9.4	6.7
P-Value	<0.01	<0.01

Table 3. Mechanism of Injury and basic demographic comparison between Austria and Germany.

	Austria n = 4,186	Germany n = 41,670	Φ (phi)
Blunt Trauma (%)	95.3	95.9	0.09
Female (%)	25.3	28.3	0.02
Age: 16-59 years (%)	66.1	63.7	0.01
Age: 60-69 years (%)	12.6	12.2	0.01
Age: 70-79 years (%)	12.2	13.7	0.01
Age: ≥ 80 years (%)	9.1	10.5	0.01
Mean Age ± SD	50.1 ± 20.3	51.3 ± 20.9	
Mean ISS ± SD	27.9 ± 11.2	28.0 ± 11.9	
ASA 3-4 (%)	11.9	16.8	0.04
AIS Head ≥ 3 (%)	56.5	56.9	0.00
AIS Thorax ≥ 3 (%)	54.8	56.7	0.01
AIS Abdomen ≥ 3 (%)	17.7	16.1	0.01
AIS Pelvic/Extremities ≥ 3 (%)	30.8	32.4	0.01
TBI isolated (%)	16.7	14.7	0.02
Mechanism of Injury (%)			
Car/Lorry	20.0	22.9	0.02
Motorcycle	12.2	13.1	0.01
Bicycle	7.4	8.9	0.02
Pedestrian	7.3	7.6	0.00
Low fall < 3m height	17.2	18.0	0.01
High Fall > 3m height	20.6	19.0	0.01
Blunt hit	4.7	2.4	0.04
Gunshot	1.5	0.8	0.02
Stabbing	1.1	1.3	0.01
Other	5.3	4.7	0.01

Figures

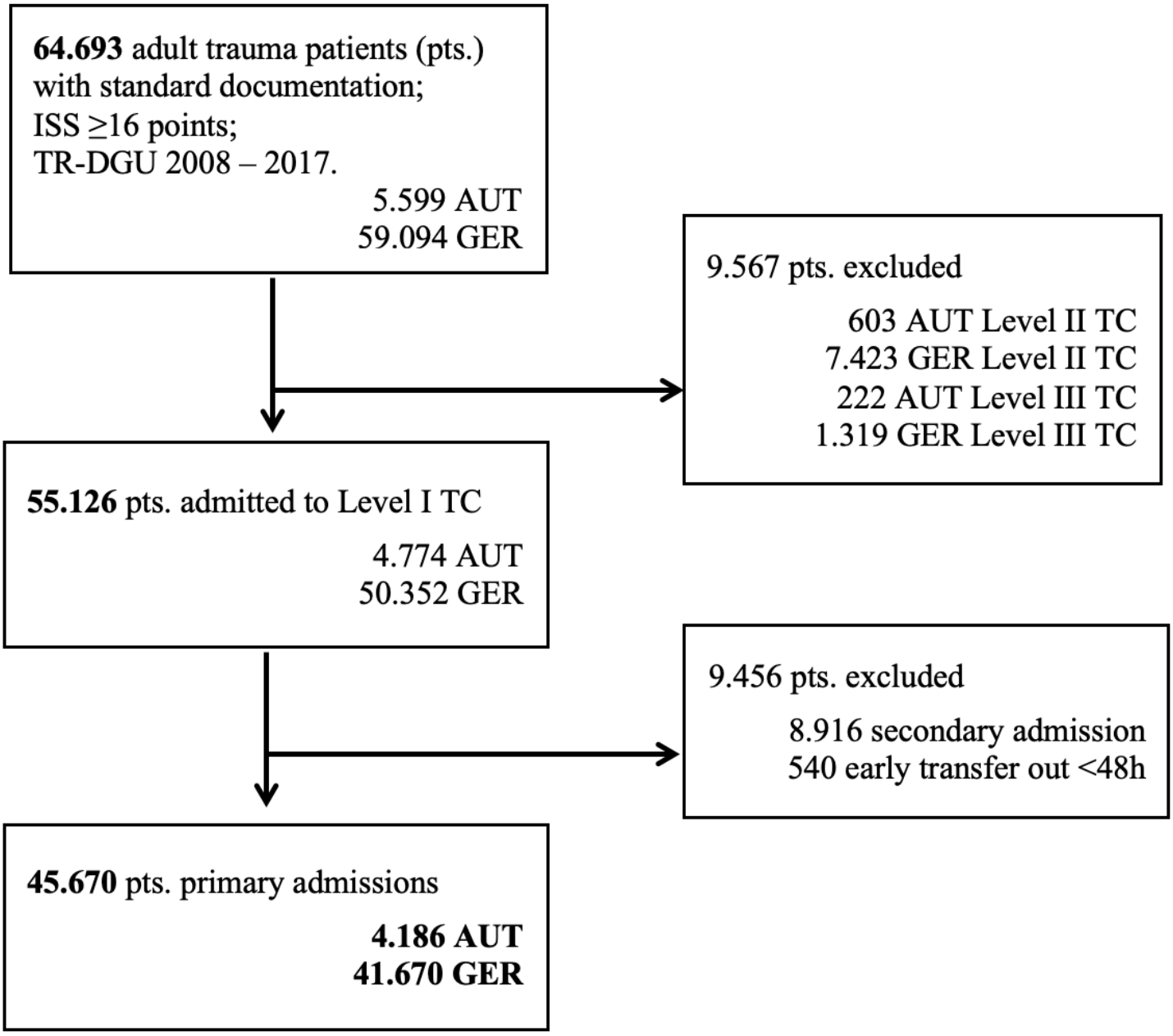

Figure 1

Study flow diagram: During the study period, inclusion criteria were met by 4.186 Austrian (AUT) and 41.670 German (GER) patients.

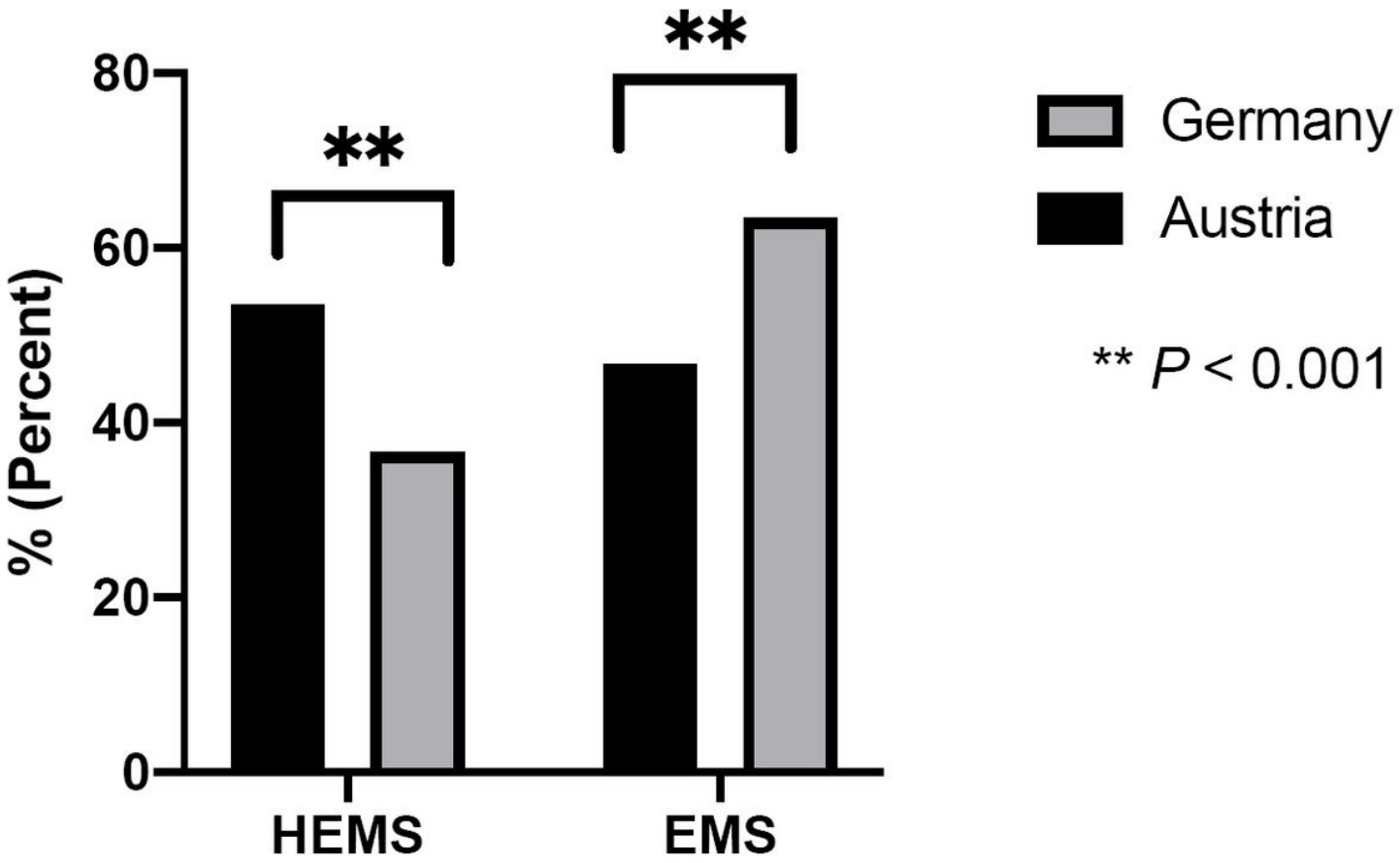

Figure 2

Mode of transportation to the TC in Austria and Germany. HEMS = Helicopter transport, EMS = Ambulance transport.

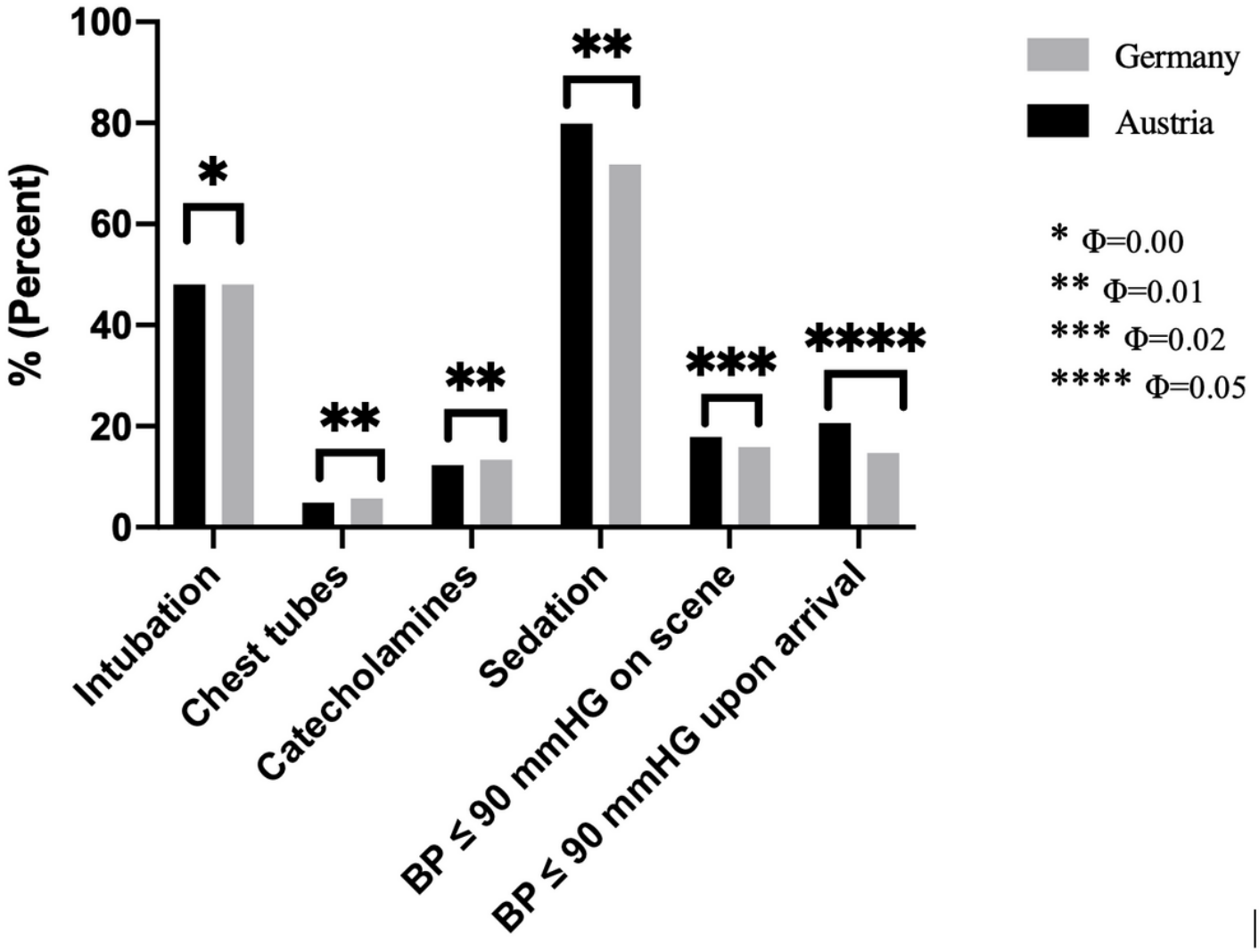

Figure 3

Pre-hospital interventions taken and differences in systolic blood pressure (BP).