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Competitive advantage gained from the use of helicopter emergency medical services (HEMS) for trauma patients: Evaluation of 1724 patients

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ABSTRACT

Objectives: The aim of the study was to analyze helicopter emergency medical service (HEMS) in comparison to EMS, in respect to patient's mortality and morbidity.
Design: From a cohort of traumatized patients (n = 1724) prospectively enrolled in the German trauma registry (DGU-R) at Frankfurt University Hospital from 2009 to 2013, 1646 could be analyzed for in-hospital mortality and short-term outcome (GOS) at discharge and compared between HEMS and EMS.
Measurements and main results: 129 patients (7.8%) died in the hospital. Unadjusted mortality was significantly lower in the HEMS group compared to EMS ($p = 0.001$). In a multiple logistic regression analysis after adjustment of variables including reanimation and age as the strongest predictors, in-hospital mortality was significantly reduced in HEMS ($p = 0.014$, OR = 0.21). Further predictors in the multiple logistic regression analysis were GCS >= 8 ($p = 0.001$), RRsys ($p < 0.001$), ISS at Head/Neck >= 3 ($p = 0.003$), and total ISS >= 9 ($p < 0.001$). Total rescue time and on scene time were associated with mortality ($p < 0.001$) but not included in the multiple logistic regression model. Without adjustment, short-term outcome (GOS) was significantly improved ($p = 0.014$). In a linear model, after adjusting for multiple variables including age, ISS Head/Neck >= 3, ISS Extremities >= 3, GCS >= 8, and RRsys as the strongest predictors ($p < 0.001$), the association remained significant ($p = 0.043$). Further predictors in the multiple linear regression analysis were total ISS >= 9 ($p = 0.002$), ISS abdomen ($p = 0.001$), and ISS Chest ($p = 0.011$).
Conclusions: A significant improvement for in-hospital survival for HEMS could be demonstrated. Especially in Germany, with a high number of secondary call outs (about 44%) after EMS has already reached the traumatized patient, HEMS must be the first choice for severely injured trauma patients. Dispatch criteria for immediate alarm of HEMS are recommended under practical considerations.

Since the introduction of helicopter emergency medical services (HEMS) in the civilian environment in the 1970s, there has been an ongoing discussion about the benefits of HEMS in emergency management of trauma care [1–7]. In earlier times, the concept of helicopter usage was intended to decrease rescue times with point to point transfer and allow specialist interventions to avoid secondary transfers. Later, the benefit of flying directly to the nearest appropriate medical center became evident. The high yearly maintenance costs of HEMS raised doubts about the utility and cost-effectiveness of this transportation mode. The cost of HEMS was reported to be high regardless of distance as compared to road ambulances [8]. The question was raised whether the use of HEMS can improve outcomes, like survival, and in which cases it is best used compared to ground emergency services. The goal of the study was to use outcome data generated at the Frankfurt University Hospital for the DGU-German Trauma Registry from 2009 to 2013 to analyze the benefits of HEMS.

Methods

Every trauma case in this study was evaluated using the structure of the TraumaRegister DGU® of the German Society for Trauma Surgery (DGU). The registry was founded in 1993, and

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[1] Most of the work in this paper is statistical analysis done by Professor Martus, head of Clinical Epidemiology and Applied Biometry of the University Hospital Tubingen, we do apply for shared first co-authorship at injury.

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today more than 300 European trauma centers collect data from the onset of the trauma until discharge from the hospital. For further evaluation, anonymous data derived from 4 parts of the collection were used. In the prehospital setting these included the accident type, procedures applied, and time intervals. At the ER and ICU, the relevant parts of the major trauma score were collected. The outcome was evaluated by calculating ISS (Injury Severity Score) and GOS (Glasgow Outcome Score) as well as survival.

At the Frankfurt Main University Hospital in Germany, a total of 1724 patient with traumatic injuries were prospectively enrolled in the data collection from 2009 to 2013 according to DGU German Trauma Registry. TraumaRegister DGU® permits trauma centers to use their own data for scientific research. The inclusion criteria were trauma patient, involved in an accident, reaching the hospital alive. Of those patients meeting these criteria, 1646 patients provided sufficient information on the mode of transportation and relevant patient data.

Table 1
Potential predictors, intermediate variables and outcome vs. mode of transportation.

Potential Predictor variable	Total (n = 1646)	HEMS (n = 183)	EMS (n = 1463)	p-value
Preclinical variables				
Male sex[1]	1171 (71.1)	127 (69.4)	1044 (71.4)	0.60
Age > = 18ys	1408 (85.5) n = 1641	153 (84.5)	1255 (86.0)	0.57
Car accident	290 (17.6) n = 1643	32 (17.5)	258 (17.7)	0.435 (chi-square test, df = 8)
Motorcycle	150 (9.1)	11 (6.0)	139 (9.5)	
Bicycle	146 (8.9)	16 (8.7)	130 (8.9)	
Pedestrian	151 (9.2)	16 (8.7)	135 (9.3)	
High Fall	226 (13.7)	22 (12.0)	204 (14.0)	
Low Fall	342 (20.8)	44 (24.0)	298 (20.5)	
Blunt	92 (5.6)	16 (8.7)	76 (5.2)	
Penetrating	86 (5.2)	11 (6.0)	75 (5.1)	
else	157 (9.5)	15 (8.2)	142 (9.7)	
GCS > = 8	1318 (80.1) n = 1646	161 (88.0)	1157 (79.1)	0.004
BPsys > = 90 mmHg	1387 (84.3) n = 1646	155 (84.7)	1232 (84.2)	0.92
Intubation	436 (26.5) n = 1601	14 (8.1)	422 (29.5)	< 0.001
Chest tube	42 (2.6) n = 1594	1 (0.6)	41 (2.9)	0.079
CPR	56 (3.4) n = 1592	1 (0.6)	55 (3.9)	0.025
Catecholamines	93 (5.7) n = 1588	2 (1.2)	91 (6.4)	0.003
Vol. Administration	1407 (85.5) n = 1518	120 (78.9)	1287 (94.2)	< 0.001
Sedation	900 (54.7) n = 1600	36 (21.1)	864 (60.5)	< 0.001
Time Variables				
Total time injury to hospital [min][2]	58 (9-598) n = 1592	45 (16-406) n = 173	60 (9-598) n = 1419	< 0.001
Time injury to alarm [min]	2 (1-243) n = 901	1 (1-243) n = 91	2 (1-210) n = 810	0.078
Time alarm to arrival [min]	9 (1-64) n = 893	6.5 (1-35) n = 72	9 (1-64) n = 821	0.001
Scene time arrival to departure [min]	26 (1-115) n = 1536	20.5 (1-59) n = 136	27 (1-115) n = 1400	< 0.001
Transportation time departure to hospital [min]	14 (1-225) n = 1572	11 (2-225) n = 162	15 (1-105) n = 1410	< 0.001
Emergency Room				
ISS head neck >=3	475 (28.9) n = 1646	33 (18.0)	442 (30.2)	0.001
ISS chest > = 3	399 (24.2) n = 1646	26 (14.2)	373 (25.5)	0.001
ISS abdomen > = 3	155 (9.4) n = 1646	11 (6.0)	144 (9.8)	0.107
ISS extremities > = 3	306 (18.6) n = 1646	19 (10.4)	287 (19.6)	0.002
Outcome				
Mortality	129 (7.8) n = 1646	3 (1.6)	126 (8.6)	< 0.001
GOS missing	10 (0.6)	0 (0.0)	10 (0.7)	
GOS 1	129 (7.8)	3 (1.6)	126 (8.6)	< 0.001
GOS 2	50 (3.0)	2 (1.1)	48 (3.3)	(chi-square test, df = 1, trend test)
GOS 3	113 (6.9)	6 (3.3)	107 (7.3)	
GOS 4	413 (25.1)	46 (25.1)	367 (25.1)	
GOS 5	931 (56.6)	126 (68.9)	805 (55.0)	

[1] n(%).
[2] Median (range).

Transportation to the nearest suitable hospital was performed either by ground emergency medical services (EMS) or helicopter emergency medical services (HEMS). The relevant variables of the database are listed in Tables 1 and 2. The primary endpoints in this study were 1) in-hospital mortality and 2) the quality adjusted short-term outcome (Glasgow outcome scale, GOS) at discharge from the hospital [9]. The patients had no registered follow up (late outcome). Patients who were already dead at the scene were not included in the data collection.

The NACA score (National Advisory Committee for Aeronautics) and TRISS (Trauma and Injury Severity Score) methodology could not be included in the analysis due to implausible and missing values. On a case by case analysis, the NACA score, vital signs, and procedures applied were not in alignment.

Statistical analysis

Univariate comparisons of predictive factors with in-hospital mortality were done using Fisher's exact test for categorical variables and the Mann-Whitney test for continuous variables (several time intervals as presented in Table 1, non-normal distribution for each variable). For GOS, chi-square tests for linear association (df = 1) and Spearman correlation coefficients were calculated. Multiple logistic regression analysis and multiple linear regression analysis were done for in-hospital mortality and GOS respectively. In both models, forward variable selection was applied with inclusion / exclusion probabilities 0.05/0.10. The level of significance was 0.05 (two-sided). For binary prognostic variables, differences of 13% between survivors (n = 1517) and deceased patients (n = 129) could be detected with a power of 80% (ex post analysis). For age, the only continuous variable in the linear and logistic regression analyses, quadratic terms were included. No significant interactions between mode of transportation and relevant predictors were found in either analyses since only three events were observed in the HEMS group. Thus, subgroup analyses are not indicated. However, motivated by the clinical importance, we descriptively present two stratified

Table 2
Potential predictors and mortality.

Potential Predictor variable	Total (n = 1646)	Survived n = 1517	Died N = 129	p-value
Preclinical variables				
HEMS	183 (11.1)	180 (11.9)	3 (2.3)	< 0.001
Male sex[1]	1171 (71.1)	1084 (71.5)	87 (67.4)	0.362
Age > = 18ys	1408 (85.5) n = 1641	1281 (84.7)	127 (99.2)	< 0.001
Car accident	290 (17.6) n = 1643	277 (18.3)	13 (10.2)	0.01 (chi-square test, df = 8)
Motorcycle	150 (9.1)	141 (9.3)	9 (7.0)	
Bicycle	146 (8.9)	137 (9.1)	9 (7.0)	
Pedestrian	151 (9.2)	137 (9.1)	14 (10.9)	
High Fall	226 (13.7)	208 (13.8)	18 (14.1)	
Low Fall	342 (20.8)	307 (20.3)	35 (27.3)	
Blunt	92 (5.6)	88 (5.8)	4 (3.1)	
Penetrating	86 (5.2)	82 (5.4)	4 (3.1)	
else	157 (9.5)	135 (8.9)	22 (17.2)	
GCS > = 8	1318 (80.1) n = 1646	1285 (84.7)	33 (25.6)	< 0.001
RRsys > = 90 mmHg	1387 (84.3) n = 1646	1314 (86.6)	73 (56.6)	< 0.001
Intubation	436 (26.5) n = 1601	332 (22.5)	104 (81.9)	< 0.001
Chest tube	42 (2.6) n = 1594	25 (1.7)	17 (13.6)	< 0.001
CPR	56 (3.4) n = 1592	17 (1.2)	39 (31.2)	< 0.001
Catecholamines	93 (5.7) n = 1588	42 (2.9)	51 (41.1)	< 0.001
Vol. Administration	1407 (85.5) n = 1518	1293 (92.2)	114 (98.3)	0.014
Sedation	900 (56.3) n = 1600	809 (54.9)	91 (72.2)	< 0.001
Time Variables				
Total time injury to hospital [min][2]	58 (9-598) n = 1593	57 (9-575) n = 1472	67 (15-598) n = 121	0.002
Time injury to alarm [min]	2 (1-243) n = 901	2 (1-243) n = 842	2 (1-165) n=59	0.321
Time alarm to arrival [min]	9 (1-64) n = 893	9 (1-64) n = 832	9 (1-29) n=61	0.791
Scene time arrival to departure [min]	26 (1-115) n = 1536	25 (1-115) n = 1414	33(5-90) n = 122	< 0.001
Transportation time departure to hospital [min]	14 (1-225) n = 1572	15 (1-225) n = 1449	14 (3-45) n = 123	0.53
Emergency Room				
ISS head neck >=3	475 (28.9) n = 1646	377 (24.9)	98 (76.0)	< 0.001
ISS chest > = 3	399 (24.2) n = 1646	342 (22.5)	57 (44.2)	< 0.001
ISS abdomen > = 3	155 (9.4) n = 1646	134 (8.8)	21 (16.3)	0.011
ISS extremities > = 3	306 (18.6) n = 1646	275 (18.1)	31 (24.0)	0.100

analyses of mortality and transportation mode (GCS, ISS). All analyses were done using SPSS for Windows (version 23).

Results

71% of trauma patients who reached the hospital alive were male. 89% reached the ER by EMS. The different categories of accidents such as car accident, high fall, or penetrating trauma, are listed in Fig. 1. An even distribution of age, sex, and accident type between HEMS and EMS is apparent.

EMS is more often confronted with low GCS. In EMS the following procedures are seen significantly more often: Intubation, catecholamines, volume administration, and sedation. In addition, EMS is more often involved in more severe trauma cases (higher ISS, except abdomen, and GOS) than HEMS.

HEMS is about 15 min faster in total time from alarm to hospital and about 7 min faster in on-scene time. In terms of cumulated probability of reaching hospital, HEMS has a significant advantage in comparison to EMS (Fig. 2). In-hospital mortality shows a steady increase in comparison to total rescue time, meaning that a significant cut-off point could not be defined (Fig. 3).

The probability of survival was higher in HEMS and for patients under 18 years of age (Table 2). Survival is significantly lower for low fall, low GCS, and low RRsys. Including volume administration, any procedure applied preclinically reduced survival. A short overall time and short on scene time increased survival. Higher ISS, especially for head / neck and chest, were disadvantageous for survival. Morbidity in HEMS and EMS regarding different ISS and GCS were analyzed in Table 5 and showed significance for lower morbidity with ISS >= 9 in the HEMS group.

Among a total of 1646 patients, 129 patients (7.8%) died in the hospital. Unadjusted mortality was significantly lower in the HEMS group compared to EMS ($p = 0.001$). In a multiple logistic regression analysis after adjustment of nine variables including reanimation and age as the strongest predictors, in-hospital mortality was significantly reduced in HEMS ($p = 0.014$, OR = 0.21) (Table 3). Further predictors in the multiple logistic regression analysis were GCS <= 8 ($p = 0.001$), ISS at Head/Neck >= 3 ($p = 0.003$), and total ISS >= 9 ($p < 0.001$). Total rescue time ($p < 0.001$) and on-scene time were associated with mortality but were not included in the multiple logistic regression model. Without adjustment, short-term outcome GOS was significantly improved ($p = 0.014$). In a linear model after adjustment for multiple variables including age, ISS Head/Neck >= 3, ISS Extremities >= 3, GCS >= 8, and RRsys as strongest predictors ($p < 0.001$), the association was significant ($p = 0.043$). Further predictors in the multiple linear regression analysis were total ISS >= 9 ($p = 0.002$), ISS abdomen ($p = 0.001$), and ISS Chest ($p = 0.011$) (Table 4).

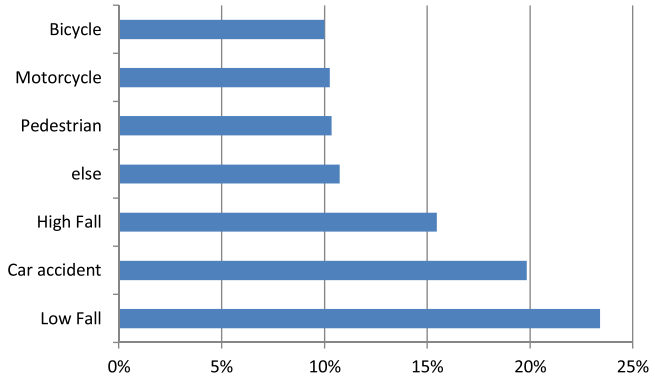

Fig. 1. Types of accidents.

Discussion

While an added value of HEMS could be demonstrated in many studies [1–5], there is an ongoing discussion about the capabilities and the cost-effectiveness of HEMS as compared to ground medical services. The annual costs of HEMS for maintenance and personnel were reported as being notably higher than for EMS [10]. Hence, the costs associated with HEMS must be justified, preferably by showing a reduction in mortality or an increase in quality adjusted survival rates [10].

Many studies have analyzed the benefit of helicopter services as compared to ground emergency medical services. Bartolacci et al. for instance, who included only patients with ISS >= 14 points, found a 50% reduction of mortality [11]. In addition, Baxt et al. could demonstrate a reduction of 21 to 50% in TRISS-predicted mortality for HEMS [12]. Another study revealed a 13% reduction in mortality for HEMS-transported patients as compared to EMS [13]. Brown et al. analyzed data from the U.S. National Trauma Databank (NTDB) regarding the impact of transportation mode on mortality and found that HEMS is an independent survival factor [14]. In contrast, Cameron found no significant survival benefit in 254 trauma patients in Melbourne, Australia [15].

Important variables to detect beneficial results of HEMS are the assessment of mortality as well as quality-adjusted survival rates. In several studies the TRISS method was used, which determines the probability of survival of a patient after adjusting for the ISS and RTS (Revised Trauma Score) scores using a specific formula [10]. However, our data were not complete enough to use this method. New Trauma and Injury Severity Score (TRISS) adjustments for survival prediction are already evaluated and rely on variables that are routinely measured during treatment of patients [16].

Incongruous NACA scores were found in the documentation of the trauma patients in this study. Only a detailed analysis of all data from one patient revealed that the NACA score and the vital signs in the database were inconsistent. Several reasons can explain the difficulty in documenting the appropriate NACA score. Knapp et al. found a discrepancy in evaluation of the NACA score based on the experience of the emergency physician [17]. The German documentation system for EMS and HEMS has 2 different evaluations of the NACA score. The initial NACA score is collected at the time of the occurrence of the trauma and the second one at the end of transportation, when reaching the ER. As documentation for the TraumaRegister DGU® starts in the ER, an inappropriate NACA score could have been used. As ISS was recorded appropriately and the NACA score was less reliable [18], it was omitted. This finding shows that there is a potential to improve the thorough collection of data during stressful EMS situations.

Usually HEMS is involved in more serious trauma cases in comparison to EMS [14]. In the Frankfurt area, HEMS was used in a different way even though the university trauma center is in the center of the city, like London. This finding shows how much the dispatch of HEMS varies and that the following discussion on survival must lead to changes in the strategy for using EMS and HEMS.

In this study, HEMS was correlated with overall reduced in-hospital mortality in a multivariable logistic regression analysis. Only 3 out of 182 patients (1.65%) undergoing HEMS transport died in hospital. Overall, there is limited information on morbidity outcomes of patients undergoing air transport. In 2004, Wang et al. [19] found that ground management was associated with a 40% higher risk of poor neurologic outcome as compared to HEMS. In this study, mortality at the date of discharge from the hospital was significantly related to HEMS with and without adjustment for relevant covariates.

Still, the studies used different and ambiguous methodologies which limit the interpretation of results and their comparability. In

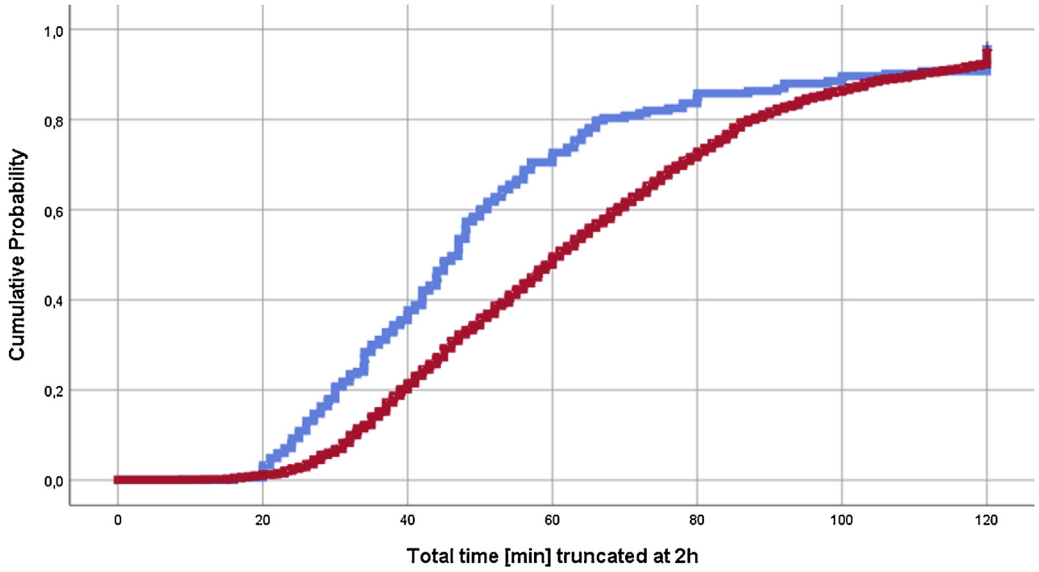

Fig. 2. Cumulative probability of reaching hospital. HEMS (left curve or blue) is faster from alarm until reaching the hospital and therefore has a significant advantage in respect to EMS (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

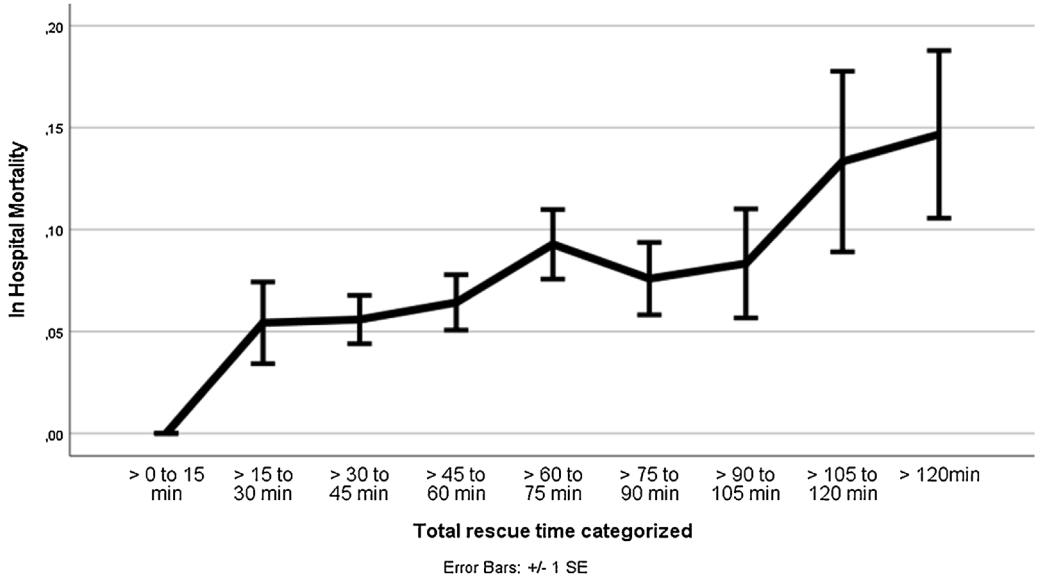

Fig. 3. Steady increase of in hospital mortality in comparison to total rescue time. The mortality rate increases with increased delay of reaching the hospital. No significant cut-off point can be seen.

this context, most of studies have various periods of observations with mostly arbitrary cut-off values as primary end points, so that these studies are not easily comparable to each other. In addition, the comparability of such results is limited due to the broad differences in flight distances, accessibility for rescue services (i.e. alpine regions), and distribution of helicopter bases in different countries. Urban helicopters depend greatly on where they are based. London, for instance, works extremely well in a highly built up population with difficult road access and a high number of trauma cases. The same is not true for somewhere like Adelaide in South Australia, where there are many intensive care paramedics in the urban area and good access to major hospitals via the road system.

Concerning the factor of the medical crew's education in both HEMS and EMS, the Frankfurt area is exceptional, as trauma physicians staff both HEMS and EMS services. In addition, EMS in Germany is associated with a rendezvous system for more serious cases. The physician is in a separate car and meets the ground ambulance at the patient's location [33]. Differences in education of HEMS and EMS crews for the Frankfurt region had to be omitted, as two different groups could not be distinguished. Even though in some locations different education levels were seen [10,17], the individual local manning of HEMS and EMS must be analyzed before a comparison can be made.

In conclusion, in this cohort of 1646 prospectively enrolled patients we found an overall significant improvement of adjusted survival rates and (only in bivariate analysis) short-term outcome in patients being transported by HEMS.

Besides survival, cost-minimization and cost-effectiveness of HEMS were assessed in various studies. Cost efficacy is usually

Table 3
Mortality - Multiple logistic regression analysis.

Predictor	Regression coefficient	Odds ratio	95% CI	p-value
Intercept	−4.89	N.A.	N.A.	N.A.
Preclinical				
HEMS vs. EMS	−1.58	0.21	0.06-0.73	0.014
Age (linear)[1]	0.78	2.19	1.63-2.95	< 0.001
Age (quadratic)[1]	0.23	1.26	1.02-1.55	0.032
GCS > = 8	−2.05	0.13	0.08-0.21	< 0.001
RRsys	−1.57	0.21	0.13-0.34	< 0.001
Emergency Room				
ISS Head/Neck > = 3	0.84	2.31	1.34-3.98	0.003
Total ISS > = 9	2.02	7.57	2.44-23.44	< 0.001

[1] Age was standardized in this analysis to avoid collinearity between the linear and the quadratic term. The regression coefficients for the unstandardized variable were -0.00895 (linear term) and 0.000560 (quadratic term). This corresponds to a quadratic function with minimum at 8 years and a quadratic increase for larger and smaller age. RRsys was coded 0 < 90, 1> = 90 mmHg.

Table 4
GOS - Multiple linear regression analysis.

Predictor	Unstandardized beta	Standard error	p-value
Intercept	4.618	0.077	N.A.
Preclinical			
HEMS vs. EMS1	0.169	0.075	0.043
Age (linear)[1]	−0.244	0.025	<0.001
Age (quadratic)[1]	−0.108	0.021	<0.001
GCS > = 8	0.877	0.066	<0.001
RRsys	0.324	0.067	<0.001
Emergency Room			
ISS Head/Neck > = 3	−0.680	0.068	<0.001
ISS Abdomen > = 3	−0.296	0.085	0.001
ISS Extremities > = 3	−0.305	0.068	<0.001
ISS Chest > = 3	−0.160	0.063	0.011
Total ISS > = 9	−0.216	0.071	0.002

[1] Age was standardized in this analysis to avoid collinearity between the linear and the quadratic term. The regression coefficients for the unstandardized variable were 0.007316 (linear term) and -0.000224 (quadratic term). This corresponds to a quadratic function with maximum at 16 years and a quadratic decrease for larger and smaller age. RRsys was coded 0 < 90, 1> = 90 mmHg.

Table 5
HEMS vs EMS stratified for measures of morbidity.

Potential Predictor variable	Total (n = 1646)	Survived (n = 1517)	Died (N = 129)	p-value
ISS < 9 (n = 650), better prognosis				
HEMS	102 (15.7)	101 (15.6)	1 (25%)	0.496
EMS	548 (84.3)	545 (84.4)	3 (75%)	
Total	650 (100)	646 (100)	4 (100)	
ISS > = 9 (n = 996), worse prognosis				
HEMS	81 (8.1)	79 (9.1)	2 (1.6)	0.004
EMS	915 (91.9)	792 (90.9)	123 (98.4)	
Total	996 (100)	871 (100)	125 (100)	
GCS < 8 (n = 328) worse prognosis				
HEMS	22 (6.7)	20 (8.6)	2 (2.1)	0.031
EMS	306 (93.3)	212 (91.4)	94 (97.9)	
Total	328 (100)	232 (100)	96 (100)	
GCS > = 8 (n = 1318), better prognosis				
HEMS	161	160 (12.5)	1 (3.0)	0.103
EMS	1157	1125 (87.5)	32 (97.0)	
Total	1318 (100)	1285 (100)	33 (100)	

addressed in terms of quality-adjusted life years or life years gained [20]. Lechleuthner et al. [21] and Gearhart et al. [22] calculated up to € 1,250,000 annually for personnel and maintenance of the helicopters for HEMS in Germany. In 1995, Nicholl et al. calculated costs for EMS of £ 97,805 compared to £ 595,000 for HEMS annually in the United Kingdom [23]. DeWing et al. reported comparable results for burn injuries [24]. None of these studies could, however, demonstrate a cost benefit of HEMS compared to EMS. Other studies have found 5-6.4 additional survivors per 100 flights in comparison to EMS, if the patient was transported by HEMS [25,26]. Mitchell et al. has found overall costs of HEMS of US$ 2,500 per life saved [27]. Compared with costs for other medical interventions (US$ 11,000-43,000 per life-year saved) these costs compared favorably. Ringburg et al. [28] performed a prospective study using the EQ-5D (per quality-adjusted life saved) and he found a cost effectiveness ratio of € 28,327 per QALY (Quality-Adjusted Life Year).

This study has shown a significant effect on survival for the use of HEMS, but it was not possible to calculate a significant cost benefit. As in many areas of medicine, the therapy of “HEMS” is already established, and society will accept the costs if the benefit in survival is apparent.

The use of HEMS is commonly expected to reduce the arrival time to reach a suitable trauma center, thereby potentially improving overall survival rates. The benefit may be increased within the first hour, a result shown in several studies [29–33]. However, in a recent study with patients transported to Level I and II trauma hospitals in North America, no association was found between mortality and pre-hospital times [34]. Ringburg et al. noted prolonged on-scene times with no difference in mortality when comparing HEMS with EMS [35].

A significant benefit for survival was found for HEMS by multiple multivariable regression analysis. There was no cut-off point found, like the often-discussed golden hour, but instead there was a steady reduction in survival with longer on-scene times and overall times. Shatney et al. [36] found that 54.7% of their 947 air-transported trauma patients arrived more quickly at the trauma center as compared to ground services. However, a recent study revealed no difference in adjusted mortality when comparing HEMS in rural and urban settings [37]. Mann et al. assessed differences in mortality three years before and after discontinuation of a rotor-wing transport device. Mortality rates were four times higher for patients transferred after the HEMS were discontinued [38]. The authors conclude that mortality increases with the loss of air transport for inter-facility transfer in rural regions. In some countries, for instance in the alpine regions, in Australia, and the US helicopters are often the only services that can reach the accident place in an appropriate time due to difficult local conditions and long distances. In another study, primary admission to a trauma center reduced mortality significantly regardless of the transportation mode [14]. Proximity to an airbase was reported to be associated with reduced risk of death for individuals residing far away from a designated trauma center [39]. No additional benefit was observed when airbases were positioned close to a trauma center or other airbases. Also, no benefit was found in another study comparing patients transferred from a hospital to specialized centers either with HEMS or EMS, contradicting recent large, retrospective National Trauma Data Bank studies [27]. All these findings support the strategy of using the transportation vehicle that will reach the final trauma center fastest.

Due to the very small number of events in the HEMS group, subgroup analyses based on significant interaction terms were not possible. However, descriptive analysis suggests that patient with higher risk seem to benefit from HEMS more than patients with lower risk. This was true for several risk factors and is shown here for unfavorable GCS (<8) and ISS (> = 9).

It was demonstrated that HEMS is an independent predictor of adjusted survival in an unadjusted bivariate analysis of short-term outcome in 1646 patients.

Looking at the reduced use of HEMS in the Frankfurt area, the dispatch criteria must be adjusted, which will in return reduce the overall costs for HEMS, as 75% of the annual costs for a HEMS

Table 6
Recommended dispatch criteria catalog. Under above criteria, HEMS should initially be released. The dispatcher can ask appropriate questions at first call to activate either EMS or HEMS. As trauma patients can deteriorate over time, strategy should be changed immediately, if further calls provide evidence that patient falls under above dispatch criteria.

Accidents with relevant head, abdominal and / or chest trauma (ISS >=9)
Signs of hemorrhagic shock, including low blood pressure
Glasgow Coma Scale < 8
When the overall time for the mission, ending in an appropriate trauma center, will be in favor of HEMS

station are fixed. The study reveals that the dispatch criteria described below will further improve the survival of patients and can be used at different locations. As on-scene times should be considered when using HEMS or EMS, the time differences must be analyzed for different areas. In the Frankfurt area, it has been calculated that HEMS has 15 min less on-scene time.

The criteria that allow the dispatcher to use simple questions to find out how severely injured the patient is and which transportation vehicle should be used are listed in Table 6. With the support of a computer-based route map system, the times to reach the level I or II trauma center will provide a basis for the decision.

Overall, a benefit of HEMS on survival could be demonstrated as well as the advantage of fast treatment and transport. In comparison to other studies, the findings cannot easily be mixed with other areas of HEMS. Dispatch criteria, time intervals, and staff training are different. It shows that on a regular basis, each trauma area should evaluate its own dispatch criteria for HEMS according to the local infrastructure to allow a larger group of patients to profit from better survival chances and, as a result, make HEMS more cost effective.

Conflict of interest

Competitive advantage gained from the use of helicopter emergency medical services (HEMS) for trauma patients: evaluation of 1725 patients from the DGU German Trauma Registry

The manuscript, including related data, figures and tables has not been previously published and is not under consideration elsewhere. The authors have no financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.injury.2018.12.018.

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