Shedding Light Into The Black Box of Out-of-Hospital Respiratory Emergencies – A Retrospective Cohort Analysis of Discharge Diagnoses, Prehospital Diagnostic Accuracy, And Predictors of Mortality

Patrick Spörl (✉ patrick.spoerl@outlook.de)

University Hospital RWTH Aachen <https://orcid.org/0000-0002-6179-9333>

Stefan K. Beckers

University Hospital RWTH Aachen

Rolf Rossaint

University Hospital RWTH Aachen

Marc Felzen

University Hospital RWTH Aachen

Hanna Schröder

University Hospital RWTH Aachen

Original research

Keywords: Respiratory distress, dyspnea, emergency medical service (EMS), diagnostic accuracy, mortality

Posted Date: October 12th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-956219/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background: Respiratory distress is one of the most common complaints of patients requiring out-of-hospital emergency services. Determining the precise discharge diagnosis in these circumstances can be challenging due to the wide range of suspected diagnoses. Moreover, these patients appear to have particularly high mortality, but little is currently known about the exact mortality rates associated with specific discharge diagnoses. Our study, therefore, aimed to determine how accurately correct diagnoses are made by EMS physicians in the out-of-hospital setting, identify examination findings that correlate with discharge diagnoses, investigate hospital mortality, and identify mortality-associated predictors.

Methods: This retrospective observational study examined emergency medical service (EMS) encounters between December 2015 and May 2016 in the city of Aachen, Germany, in which an EMS physician was present at the scene. Adult patients were included if the EMS physician initially detected dyspnea, low oxygen saturation, or pathological auscultation findings at the scene ($n = 719$). By linking out-of-hospital data to hospital records, including initial blood gas analysis, a discharge diagnosis was assigned to each EMS encounter, and the outcome was analyzed. Binary logistic regressions were used to search for associations between pathological findings and discharge diagnoses, as well as predictors of hospital mortality.

Results: The overall diagnostic accuracy was 69.9% (485/694). The highest diagnostic accuracies were observed in asthma ($15/15 \triangleq 100\%$), hypertensive crisis ($28/33 \triangleq 84.4\%$), and COPD exacerbation ($114/138 \triangleq 82.6\%$), and the lowest accuracies were observed in urinary tract infection ($14/35 \triangleq 40\%$), pulmonary embolism ($8/18 \triangleq 44.4\%$), and pneumonia ($70/142 \triangleq 49.3\%$). The overall hospital mortality rate was 13.8% (99/719). The highest hospital mortality rates were seen in pneumonia ($44/142 \triangleq 31\%$) and urinary tract infection ($7/35 \triangleq 20\%$). Potential risk factors for hospital mortality identified in this study were reduced vigilance, low oxygen saturation, increasing age, blood gas analysis (BGA) results associated with metabolic acidosis, and an incorrect out-of-hospital diagnosis by the EMS physician.

Conclusions: Our data highlight the diagnostic uncertainties and high mortality in out-of-hospital emergency patients presenting with respiratory distress. The identified predictors could help in early detection of patients at risk in the future.

Background

Emergency patients presenting with respiratory distress pose a major challenge to emergency medical service (EMS) professionals. On the one hand, available studies indicate that these patients have a markedly higher mortality rate than patients presenting with other complaints (1–3). On the other hand, the high number of differential diagnoses and limited diagnostic options complicate accurate diagnosis in an out-of-hospital setting. Previous studies conducted in out-of-hospital settings (4–6) and emergency departments (2, 7, 8) have shown a wide range of possible causes of respiratory distress. This is a relevant issue because the available treatment algorithms are mostly based on the suspected underlying

disease. An incorrect suspected diagnosis may result in the initiation of nonindicated procedures and a lack of indicated procedures, leading to a worse outcome (9). Reliable out-of-hospital diagnosis is thus essential for effective out-of-hospital therapy. However, how accurate are EMS professionals in identifying the correct discharge diagnosis? To date, few studies have drawn conclusions about the diagnostic accuracy of EMS professionals in patients presenting with respiratory distress. Two previous studies highlight that the diagnostic error rates in these emergencies appear to be very high (10, 11). However, detailed data on the diagnostic accuracy of specific discharge diagnoses are often missing.

Even though this patient population seems to be particularly challenging to diagnose and is often critically ill, there are no widely accepted diagnostic algorithms for the complaint of respiratory distress.

Objectives

The primary goal of this study is to identify the discharge diagnoses of the analyzed emergencies to determine the diagnostic accuracy of EMS physicians in an out-of-hospital setting. In addition, it should be investigated which initial examination findings correlate with discharge diagnoses. The second focus is to analyze the hospital mortality of this patient population to identify predictors of mortality to detect at-risk patients early in the future.

Methods

Study Design

This retrospective observational study was conducted within the EMS system in the city of Aachen, Germany, during a 6-month observation period (December 2015 to May 2016). All patients who presented with a respiratory problem and were treated by a physician-staffed emergency medical team (PEMT) were included in the analysis. The dataset was collected exclusively for the purpose of this study.

EMS system and operating area

The EMS in Germany is based on a two-tiered care system. An ambulance, manned by two paramedics, is dispatched after receiving an emergency call. The emergency dispatcher can also alert a PEMT staffed by an EMS physician and a paramedic. The PEMT is routinely alerted in potentially life-threatening cases (e.g., cardiac arrest or severe respiratory failure). In addition, it can be requested by an ambulance whenever further medical support is needed at the scene.

Since 2014, the city of Aachen has also implemented a telemedical support system that enables paramedics to consult a remote EMS physician (12). The present study, however, only examined cases in which an EMS physician was at the scene.

Two 24/7 PEMTs, as well as 12 ambulances, serve the city of Aachen, which has approximately 250,000 inhabitants. All EMS physicians are experienced anesthesiologists who are in at least the 4th year of their residency at the University Hospital RWTH Aachen. They must have spent at least one year in intensive

care medicine and passed an 80-hour course in emergency medicine. Three primary care hospitals and one university hospital were available for admission in the city of Aachen during the study period.

Patient selection and data collection

We included all PEMT encounters in which patients were at least 18 years old and the EMS physician documented dyspnea, low oxygen saturation ($\text{SpO}_2 < 90\%$), or pathological auscultation findings initially at the scene. Figure 1 lists the inclusion and exclusion criteria we applied to identify adult nontraumatic respiratory emergencies.

Data acquisition was based on all items from the PEMT standardized protocols and was complemented with data from hospital records. The data from hospital records were manually collected and linked in accordance with data protection regulations. For this purpose, all four hospitals in the city of Aachen provided access to their hospital information systems. Data from the following data sources were analyzed: handwritten PEMT standardized protocols, hospital discharge letters, and, if available, digital emergency department protocols and initial blood gas analyses.

Terminology used in diagnoses

Diagnoses suspected by the PEMT are referred to as “out-of-hospital diagnoses” in this paper. The actual reason for the emergency call according to the hospital discharge letter is referred to as the “discharge diagnosis”. By reviewing the hospital data, we ensured that the diagnoses that resulted from complications during hospitalization were not considered discharge diagnoses. We standardized the terminology of the diagnoses by summarizing synonymous diseases. The diagnoses of “pulmonary edema” and “heart failure” were combined under the term “decompensated heart failure”. All discharge diagnoses were classified into one of those shown in Figure 2.

Diagnostic accuracy by the PEMT

To assess diagnostic accuracy, we carefully analyzed each hospital discharge letter and PEMT protocol to determine the consistency of the diagnoses. We considered each documented out-of-hospital diagnosis and defined it as correct if any of them matched the discharge diagnosis.

In cases where the PEMT suspected a diagnosis of “non-ST segment elevation acute coronary syndrome” (NSTEMI) or “pulmonary embolism”, the out-of-hospital diagnosis was defined as correct even if the only discharge diagnosis made was “exclusion of ACS/pulmonary embolism” because exclusion is not possible with certainty in an out-of-hospital setting.

Blood gas analysis (BGA)

All BGA results were obtained in the emergency departments (to date, blood gas analysis is not available in an out-of-hospital setting in the city of Aachen). It was often unclear whether BGA was performed with arterial, capillary, or venous blood. Therefore, we extended the reference ranges for pCO_2 , standard bicarbonate, and lactate to cover blood from all three sources. The reference ranges used are listed in

Additional file 6. Because the reference ranges for pO₂ differ widely depending on the source of the blood, we did not consider pO₂.

Statistical analysis

Statistical analysis was performed using SPSS® version 26 (IBM Corporation, Armonk, New York, USA). Two-sided p values <0.05 were considered significant.

Identification of findings upon physical examination associated with discharge diagnoses

In Figure 4 and **Additional file 3**, we used binary logistic regressions to test out-of-hospital and emergency department examination findings for associations with discharge diagnoses (all evaluated variables are listed below in Figure 4). First, univariable analyses were performed for each diagnosis. Multivariable analysis was performed in the second step to determine which pathological findings were independently associated with their respective discharge diagnoses. For this purpose, all variables with a univariable p value < 0.20 were considered.

Due to the high number of missing data points for some variables (presented in **Additional file 4**), the case count for the multivariable analyses was severely reduced. We considered the resulting risk of incorrect conclusions to be substantial and performed multiple imputations for all examination findings presented in **Additional file 4** to minimize the risk of bias. The missing data were presumed to be missing at random, and 20 imputed datasets were generated using the fully conditional specification method based on the Markov chain Monte Carlo method. Multivariable analyses were performed on all imputed datasets, and the reported data represent the pooled results.

Predictors of hospital mortality

In Table 2 and **Additional file 5**, we examine the association of predictors with hospital mortality using binary logistic regression. All assessed variables (listed in detail below in Table 2) were first tested using univariable analysis. Since age had an impact on mortality, we considered it a confounder and adjusted the univariable results. In the next step, a multivariable analysis was performed to determine which pathologies were independently associated with hospital mortality. For this purpose, all examination findings with a univariable p value < 0.20 were considered. Because of the many missing data points for different examination findings, multiple imputations were performed, analogous to the procedure described above.

In Table 3 and **Additional file 6**, the BGA results were reviewed for their impact on hospital mortality using univariable analysis.

Results

In total, 928 PEMT encounters were considered according to the inclusion and exclusion criteria. These adult nontraumatic respiratory emergencies represented 24.1% of all PEMT encounters in the city of Aachen during the study period (n = 3,856). The study population consisted of 719 encounters in which hospital records were available.

Characterization of the study population

Table 1 characterizes the patient population and presents information on PEMT encounters and hospital follow-up. **Additional file 1** shows further details grouped by age.

Table 1
Characterization of patients, PEMT encounters, and hospital follow-up

Age (years), mean (standard deviation)	70.2 (16.7)	
Female sex, n (%)	335 (46.9)	
PEMT alerting		
Initial alerting on emergency call, n (%)	626 (87.1)	
Alerting by ambulance on scene, n (%)	93 (12.9)	
Location of PEMT encounters		
Flat, n (%)	493 (68.6)	
Senior citizen's home, n (%)	122 (17.0)	
General practice, n (%)	34 (4.7)	
Street, n (%)	24 (3.3)	
Others, n (%)	46 (6.4)	
Rating of disease severity by PEMT (NACA score)		
NACA score = 2, n (%)	4 (0.6)	
NACA score = 3, n (%)	207 (28.8)	
NACA score = 4, n (%)	289 (40.2)	
NACA score = 5, n (%)	135 (18.8)	
Hospital treatment		
Outpatient treatment in the emergency department, n (%)	74 (10.3)	
Inpatient hospital treatment, n (%)	645 (89.7)	
ICU admission, n (%)	161 (22.4)	
In-hospital death, n (%)	99 (13.8)	
Length of stay in hospital (days), mean (standard deviation)	8.7 (12.5)	
Frequency of pathological findings	Initially at the scene	At the emergency department**

PEMT *physician-staffed emergency medical team*; NACA 2 *outpatient treatment*; NACA 3 *inpatient treatment necessary*; NACA 4 *acute danger to life cannot be ruled out*; NACA 5 *acute danger to life*; ICU *intensive care unit*; SpO2 *peripheral oxygen saturation*; * *These examination findings were not requested on the PEMT protocol and therefore were not consistently documented*; ** *some data are missing because some emergency department protocols were not accessible*.

Age (years), mean (standard deviation)	70.2 (16.7)	
Dyspnea, n (%)	631 (87.8)	no data
Wheezing upon auscultation, n (%)	188 (26.1)	174 (24.2)
Crackles upon auscultation, n (%)	181 (25.2)	146 (20.3)
Silent lung upon auscultation, n (%)	no data*	46 (6)
Lower extremity edema, n (%)	no data*	101 (14)
Respiratory rate, data available, n (%)	531 (73.9)	417 (58.0)
≥ 22/minute, n (% regarding the available data)	200 (37.7)	156 (37.4)
SpO2, data available, n (%)	714 (99.3)	466 (64.8)
< 90%, n (% according to available data)	308 (43.1)	86(18.5)
Systolic blood pressure, data available, n (%)	698 (97.1)	530 (73.7)
< 100 mmHg, n (% regarding the available data)	49 (7.0)	31 (5.8)
Heart rate, data available, n (%)	710 (98.7)	518 (72.0)
> 100/minute, n (% regarding the available data)	302 (42.5)	133 (25.7)
Body temperature, data available, n (%)	465 (64.7)	204 (28.4)
≤ 36°C, n (% regarding the available data)	47 (10.1)	36 (17.6)
≥ 38°C, n (% regarding the available data)	85 (11.8)	39 (19.1)
Glasgow Coma Scale, data available, n (%)	706 (98.2)	168 (23.4)
< 15, n (% regarding the available data)	154 (21.8)	35 (20.8)
PEMT <i>physician-staffed emergency medical team</i> ; NACA 2 <i>outpatient treatment</i> ; NACA 3 <i>inpatient treatment necessary</i> ; NACA 4 <i>acute danger to life cannot be ruled out</i> ; NACA 5 <i>acute danger to life</i> ; ICU <i>intensive care unit</i> ; SpO2 <i>peripheral oxygen saturation</i> ; * <i>These examination findings were not requested on the PEMT protocol and therefore were not consistently documented</i> ; ** <i>some data are missing because some emergency department protocols were not accessible</i> .		

Discharge diagnoses and diagnostic accuracy of the PEMT

A total of 793 discharge diagnoses were found. Two discharge diagnoses were defined in 92 cases, three were defined in one case, and the discharge diagnosis remained unclear in 19 cases. Pneumonia ($n = 142 \pm 17.9\%$), COPD exacerbation ($n = 138 \pm 17.4\%$), and decompensated heart failure ($n = 125 \pm 15.8\%$) accounted for 51.1% ($n = 405$) of all discharge diagnoses. Figure 2 lists all discharge diagnoses made in our study and shows the diagnostic accuracy of the PEMT. Further descriptive data on demographics, physical examination findings, and hospitalization details for the most frequent discharge diagnoses are presented in **Additional file 2**.

PEMT: *physician-staffed emergency medical team*; COPD: *chronic obstructive pulmonary disease*; ACS: *acute coronary syndrome*; NSTEMI: *non-ST segment elevation ACS*; STEMI: *ST-elevation myocardial infarction*; total of number of discharge diagnoses made: 793

Overall, the diagnostic agreement between out-of-hospital diagnoses and discharge diagnoses was 69.9% (n = 485), and the error rate was 30.1% (n = 209). Diagnostic accuracy could not be assessed in 25 of 719 encounters (3.5%) because either no out-of-hospital diagnosis was documented (n = 6) or the discharge diagnosis remained unclear (n = 19). Therefore, diagnostic accuracy analysis was performed on the remaining 694 encounters.

Figure 3 shows which out-of-hospital diagnoses the PEMTs suspected when they failed to identify the correct discharge diagnosis.

Characterization of discharge diagnoses and identification of associated findings upon physical examination

Figure 4 displays all out-of-hospital and emergency department examination findings that showed an independent association with the diagnoses evaluated. Detailed results of the statistical analysis are provided in **Additional file 3**.

We found that some initial out-of-hospital examination findings were not documented (and probably not measured) in a relevant proportion of PEMT encounters (**Additional file 4**). For example, respiratory rate was not documented in 26.1%, body temperature in 35.3%, and numeric rating scale in 39.9% of encounters.

Hospital mortality and the search for associated predictors

The overall hospital mortality rate in our study was 13.8% (99/719). Figure 5 shows the mortality rates of the most frequent discharge diagnoses and the respective diagnostic error rates of PEMTs.

In Table 2, we reviewed predictors for their association with hospital mortality. In multivariable analysis, reduced vigilance (GCS < 15), low oxygen saturation (SpO₂ < 90%), and increasing age were associated with a higher risk of death, whereas wheezing upon auscultation was associated with lower mortality. The association between age and mortality was particularly evident for the 80- to 89-year-old group, while it was not seen for those over 89 years old (for further details see **Additional file 5**). Two discharge diagnoses also showed significant effects: pneumonia was associated with a higher risk of hospital death, whereas COPD exacerbation was associated with a lower risk of hospital death. Furthermore, out-of-hospital misdiagnosis by the PEMT showed a correlation with increased hospital mortality.

Table 2
Predictors of hospital mortality

	Univariable analysis	
	OR (95% CI)	p value
Age		
Age by 1 year increase	1.044 (1.026-1.062)	<0.001
Age < 60 years	0.216 (0.098-0.475)	<0.001
Age 80–89 years	2.487 (1.605-3.854)	<0.001
Univariable analysis adjusted for age		
	OR (95% CI)	p value
PEMT assessment		
Acute danger to life (NACA score = 5)	4.357 (2.663-7.126)	<0.001
Misdiagnosis by the PEMT	1.744 (1.111-2.739)	0.016
Discharge diagnoses		
Pneumonia	4.261 (2.713-6.692)	<0.001
COPD exacerbation	0.239 (0.102-0.557)	0.001
Multivariable analysis using multiple imputations		
	OR (95% CI)	p value
Age by 1 year increase	1.034 (1.012-1.058)	0.003
Pathological examination findings		
Reduced vigilance (GCS < 15)	2.988 (1.635-5.462)	<0.001
Low oxygen saturation (SpO2 < 90%)	2.597 (1.428-4.722)	0.002
Wheezing upon auscultation (emergency department)	0.403 (0.166-0.975)	0.044

Binary logistic regression: only significant results are shown; examination findings were tested using multivariable analysis to identify pathologies that are independent predictors for mortality; OR: odds ratio; 95% CI: 95% confidence interval of OR; GCS: Glasgow Coma Scale; SpO2: peripheral oxygen saturation; PEMT: physician-staffed emergency medical team; COPD: chronic obstructive pulmonary disease. The following variables were reviewed for associations with hospital mortality: age, sex, discharge diagnoses with $n > 10$, misdiagnosis by the PEMT, assessment of an acute danger to life by the PEMT (NACA-Score ≥ 5), prehospital findings: systolic blood pressure < 100 mmHg, heart rate > 100/min, peripheral oxygen saturation < 90%, respiratory rate ≥ 22 /min, body temperature $\geq 38^{\circ}\text{C}$, body temperature $\leq 36^{\circ}\text{C}$,

Glasgow Coma Scale < 15, numeric rating scale ≥ 1 , crackles upon auscultation, wheezing upon auscultation, emergency department findings: crackles upon auscultation, wheezing upon auscultation, silent lung upon auscultation, and lower extremity edema. Detailed results of logistic regression are presented in Additional file 5.

Hospital mortality and initial blood gas analysis

Initial blood gas analyses were not performed in half of the cases. PH and pCO₂ results were available in 364 cases (50.6%), and standard bicarbonate was available in 342 cases (47.6%).

Because lactate measurement was exclusively part of the BGA at the participating university hospital, lactate results were available only in 192 cases (26.7%). Results of the initial blood gas analysis (Table 3) show that metabolic acidosis can be considered a risk factor for mortality. This association was evident in all BGA results related to metabolic acidosis (decreased pH, decreased standard bicarbonate, hyperventilation, and increased lactate). A normative pH and normative lactate can be considered protective factors according to our data. More detailed results are shown in **Additional file 6**.

Table 3
Associations between initial emergency department BGA results and hospital mortality

	OR (95% CI)	p value
pH-value		
pH $\geq 7.35 \leq 7.45$ (reference range)	0.511 (0.264-0.989)	0.046
pH < 7.35	2.718 (1.434-5.151)	0.002
pH < 7.3	3.160 (1.592-6.272)	0.001
pH < 7.25	2.951 (1.324-6.580)	0.008
pH < 7.2	3.211 (1.175-8.771)	0.023
pCO₂		
pCO ₂ < 3,6 kPa (27 mmHg)	4.013 (1.155-13.944)	0.029
Standard bicarbonate		
HCO ₃ by 1 mmol/L increase	0.895 (0.839-0.954)	0.001
HCO ₃ < 17 mmol/L	19.185 (4.750-77.493)	<0.001
HCO ₃ < 21 mmol/L	3.747 (1.732-8.105)	0.001
Lactate		
Lactate by 1 mmol/L increase	1.646 (1.251-2.165)	<0.001
Lactate ≤ 2.2 mmol/L (reference range)	0.274 (0.118-0.634)	0.002
Lactate > 2.2 mmol/L	3.652 (1.578-8.449)	0.002
Lactate > 3.0 mmol/L	4.034 (1.631-9.975)	0.003
Lactate > 4.0 mmol/L	7.750 (2.783-21.585)	<0.001
Lactate > 5.0 mmol/L	7.273 (1.948-27.151)	0.003
Pathological BGA findings*:		
Metabolic acidosis	8.314 (2.936-23.542)	<0.001
Lactate acidosis	6.708 (1.280-35.168)	0.024
Metabolic acidosis of causes other than lactate	6.708 (1.280-35.168)	0.024

Binary logistic regression for univariable analyses: only significant results are shown; pH: hydrogen potential; pCO₂: partial pressure of carbon dioxide; HCO₃: standard bicarbonate; OR: odds ratio; 95% CI: 95% confidence interval of OR; * pathological BGA findings are defined as follows: metabolic acidosis: (pH < 7.35 and HCO₃ < 21 mmol/L and pCO₂ $\leq$ 6.7 kPa (50 mmHg)) or (pH < 7.35 and pCO₂ $\leq$ 6.7 kPa (50 mmHg) and lactate > 5.0 mmol/L); lactate acidosis: pH < 7.35 and pCO₂ $\leq$ 6.7 kPa (50 mmHg) and

lactate > 5.0 mmol/L; metabolic acidosis of causes other than lactate: pH < 7.35 and HCO₃ < 21 mmol/L and pCO₂ ≤ 6.7 kPa (50 mmHg) and lactate ≤ 2.2 mmol/L; further details are provided in Additional file 6.

Discussion

This study of patients presenting with respiratory distress examined causal discharge diagnoses, the diagnostic accuracy of EMS physicians in an out-of-hospital setting, and hospital mortality. Our data show that diagnostic accuracy and hospital mortality differ widely depending on the discharge diagnoses. Overall, the high portions of misdiagnosis and the high hospital mortality rate confirm the assumption that this patient population seems to be particularly challenging and critically ill.

Discharge diagnoses and diagnostic accuracy of the PEMT

The high proportion of 24.1% of all PEMT encounters during the study period shows the great relevance of nontraumatic respiratory emergencies in the daily routine of EMS. The highest prevalence was found for pneumonia, COPD exacerbation, and decompensated heart failure. This is largely consistent with the results of comparable out-of-hospital (5, 6) and emergency department (7, 8) studies. Seven other discharge diagnoses accounted for more than 25% of PEMT encounters in our study. This demonstrates that EMS professionals must consider a wide range of differential diagnoses when treating patients with respiratory distress.

Studies assessing the diagnostic accuracy of EMS professionals in respiratory emergencies are rare and differ in the way diagnostic accuracy was calculated.

In our survey, the overall proportion of PEMT misdiagnoses was 30.1%. In two former PEMT studies from Germany, the highest portions for misdiagnosis (26% and 41%) were found in patients admitted for dyspnea (10, 11). In contrast, two other German PEMT studies observed the highest misdiagnosis rates in neurological emergencies (13, 14). Interestingly, these studies did not show a notable accumulation of misdiagnoses in respiratory emergencies. It is noticeable that one of them – the study by Arntz et al. (13) – differs in the qualifications of the EMS physicians involved. While 68% of the EMS physicians in this study were internists, only anesthesiologists worked as EMS physicians in all other studies (including ours). The strikingly low misdiagnosis rate described by Arntz et al. may be because internist-trained EMS physicians have more clinical experience in diagnosing patients with respiratory problems.

Looking at the individual discharge diagnoses in our study, there were huge differences in diagnostic confidence. Low diagnostic accuracy is particularly notable for pneumonia, which was the most frequent discharge diagnosis in our study. Pneumonia was also associated with the highest hospital mortality rate (31%), the highest rate of ICU admissions (37.3%), and a significantly increased likelihood of in-hospital death. This observation is supported by the paramedic study by Kauppi et al., which also found that patients with respiratory distress due to pneumonia had the highest mortality (5). Our analysis of PEMT

misdiagnoses found that EMS physicians often suspected COPD exacerbation or decompensated heart failure when pneumonia was actually present.

It is less surprising that diagnostic accuracy was low for urinary tract infection. Presumably, few EMS professionals think primarily of a urinary tract infection in patients presenting with respiratory distress. However, patients admitted with urinary tract infection showed the second highest mortality rate of 20%. Closer examination of these cases revealed that a second discharge diagnosis (e.g., COPD exacerbation, pneumonia, and decompensated heart failure) was made in 12 of 35 patients admitted with a urinary tract infection. In these cases, it cannot be excluded that the respiratory symptoms were caused by these second discharge diagnoses. Urinary tract infections were at least concomitantly present in 4.9% of analyzed PEMT encounters and should therefore be considered a relevant differential diagnosis and cause for respiratory distress.

One former emergency department study of elderly patients with respiratory distress described that misdiagnosis resulted in worse patient outcomes (9). In our study, the EMS physician made an incorrect diagnosis in 42.7% of all cases of in-hospital death. Using logistic regression, we found that an incorrect out-of-hospital diagnosis was associated with a significantly increased probability of hospital mortality. It can therefore be suspected that an increase in diagnostic accuracy would result in a decrease in morbidity and mortality.

Pathological findings associated with discharge diagnoses

The two strongest associations we found were of prehospital wheezing being strongly associated with asthma (odds ratio 38.8) and lower extremity edema being associated with decompensated heart failure (odds ratio 13.7). Our data indicate that a clear recommendation can be made for thorough auscultation of the lungs and evaluation of lower extremity edema in all patients with respiratory distress.

Several findings correlated with low or moderate odds ratios with discharge diagnoses. It became clear that many routine parameters (e.g., body temperature and GCS) provide important information about discharge diagnoses. Nevertheless, some of these parameters were not documented in many encounters. Our results indicate that measurement of all these routine parameters in any respiratory emergency is advisable. This even allows for the identification of unexpected pathological findings (e.g., high body temperature), which can provide essential hints for the correct diagnosis.

Because out-of-hospital diagnosis can be very challenging, a diagnostic algorithm seems to be useful to identify the correct diagnosis and initiate appropriate therapy. Further studies on the relationships between examination findings, medical history, and discharge diagnoses could aid development of an effective diagnostic algorithm. In addition, EMS professionals should be better prepared for the challenging diagnosis of respiratory emergencies through focused education and training in the future.

Some emergency department studies have shown that the use of point-of-care ultrasound (POCUS) in respiratory emergencies can reduce the number of differential diagnoses and increase diagnostic

accuracy (15–17). Out-of-hospital use of ultrasound and training of EMS professionals in POCUS therefore have the potential to increase diagnostic confidence.

Hospital mortality and the search for associated predictors

The hospital mortality rate in our study was 13.8%, which was comparable to that of three similar EMS studies from Scandinavia involving patients with dyspnea (1, 4, 5). These studies reported hospital or 30-day mortality rates of 11%, 12.3% and 13.2%, respectively. We attribute the slightly higher mortality in our study to the fact that only EMS encounters involving EMS physicians were analyzed and that these encounters presumably represent a particularly critical subset of all respiratory emergencies.

Unsurprisingly, the ICU admission rate in our study was also very high (22.4%). The consistent above-average mortality and ICU admission rates highlight that patients with respiratory distress should be considered high-risk.

According to our analysis, decreased vigilance, low oxygen saturation, and increasing age can be considered independent predictors for hospital mortality. Two former emergency department studies that included patients with any complaint also found that decreased vigilance was an independent risk factor for 30-day mortality (3, 18). The same conclusion was made in an EMS study of patients with the complaint of dyspnea (19). Two of these studies (3, 19) similarly reported that low oxygen saturation was a risk factor for mortality. Patients with dyspnea have a higher risk of death with increasing age, which has also been shown by previous studies (9, 19).

Hospital mortality and initial blood gas analysis

Examination of the initial BGA results shows that metabolic acidosis appears to be a strong risk factor for death. Closer examination demonstrated that both lactate acidosis and metabolic acidosis of another origin showed this association.

Surprisingly, there is little evidence of the prognostic value of BGA results in patients with respiratory distress. Two previous studies showed that acidosis led to a higher risk of mortality or ICU admission in patients with dyspnea (20, 21). That initial hyperlactatemia is an independent predictor of mortality in unselected emergency department patients has been demonstrated by numerous studies (22–24). Our results highlight that elevated lactate is an important prognostic parameter even in emergency patients with respiratory distress. Therefore, BGA, including lactate, should be routinely measured in all patients presenting with respiratory distress.

Limitations

Compared to other studies, our study is based on a relatively small sample size. Because we examined only PEMT encounters during winter and spring, our results do not allow for conclusions about all respiratory emergencies throughout an entire year. Rather, it can be assumed that we studied a particularly critically ill subset of this patient population. Since the evaluation of diagnostic accuracy was not blinded, it cannot be excluded with certainty that it was over- or underestimated. The many missing data in some examination findings posed challenges for the multivariable analyses. We tried to

compensate them by running multiple imputations. The sample size for BGA analysis was particularly small, as BGA results were obtained from only half and lactate was measured in a quarter of the encounters.

Conclusion

Our study provides detailed insights into the diagnostic accuracy of EMS physicians and causing discharge diagnoses in respiratory emergencies. We showed that the overall diagnostic uncertainty was high but varied greatly between discharge diagnoses. The correlations found between initial examination findings and discharge diagnoses may help to increase diagnostic accuracy in the future. In this regard, the development of a diagnostic algorithm for respiratory emergencies seems useful.

Analysis of hospital mortality shows that emergency patients presenting with respiratory distress have a markedly high risk of in-hospital death. According to our data, decreased vigilance, low oxygen saturation, increasing age, and metabolic acidosis can be considered risk factors for hospital mortality.

Abbreviations

°C: degrees Celsius;

ACS: acute coronary syndrome;

BGA: blood gas analysis;

CI: confidence interval;

COPD: chronic obstructive pulmonary disease;

EMS: emergency medical service;

GCS: Glasgow Coma Scale;

HCO₃: standard bicarbonate;

ICU: intensive care unit;

NACA: National Advisory Committee of Aeronautics;

NRS: numeric rating scale;

NSTE-ACS: non-ST segment elevation acute coronary syndrome;

OR: odds ratio;

pCO₂: partial pressure of carbon dioxide;

pH: hydrogen potential

POCUS: point-of-care ultrasound;

PEMT: physician-staffed emergency medical team;

pO2: partial pressure of oxygen;

SpO2: peripheral oxygen saturation;

STEMI: ST-elevation myocardial infarction

Declarations

Ethics approval and consent to participate

The study plan was submitted to the Ethics Committee of the Medical Faculty of RWTH Aachen University. In a statement dated July 9, 2018, the committee indicated that an application was not necessary and that there were no ethical or legal objections to the study (file number EK 180/18).

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Authors' contributions

PS, SKB, HS, and MF planned the study design. PS collected the data and performed the statistical analysis. The results and their interpretation were discussed by PS, MF, SKB, HS and RR. PS wrote the draft of the manuscript. MF, SKB, HS, and RR contributed to the correction of the manuscript. All authors approved the submitted version and all modified versions of the manuscript.

Acknowledgments

The authors would like to thank the representatives of the participating hospitals for their kind cooperation in evaluating the hospital records. In particular, we would like to thank Mrs. Ulrike Bocker, Mrs. Monique Tasidis, and Dr. Michael Schöntag for their capable and patient support. Furthermore, we thank Dr. Martin Klasen for his competent support in planning the statistical analysis.

References

1. Bøtker MT, Terkelsen CJ, Sørensen JN, Jepsen SB, Johnsen SP, Christensen EF, et al. Long-Term Mortality of Emergency Medical Services Patients. *Ann Emerg Med*. 2017;70(3):366–73.e3.
2. Mockel M, Searle J, Muller R, Slagman A, Storchmann H, Oestereich P, et al. Chief complaints in medical emergencies: do they relate to underlying disease and outcome? The Charité Emergency Medicine Study (CHARITEM). *Eur J Emerg Med*. 2013;20(2):103–8.
3. Barfod C, Lauritzen MM, Danker JK, Sölétormos G, Forberg JL, Berlac PA, et al. Abnormal vital signs are strong predictors for intensive care unit admission and in-hospital mortality in adults triaged in the emergency department - a prospective cohort study. *Scand J Trauma Resusc Emerg Med*. 2012;20:28.
4. Lindskou TA, Pilgaard L, Søvsø MB, Kløjgård TA, Larsen TM, Jensen FB, et al. Symptom, diagnosis and mortality among respiratory emergency medical service patients. *PLoS One*. 2019;14(2):e0213145.
5. Kauppi W, Herlitz J, Magnusson C, Palmér L, Axelsson C. Characteristics and outcomes of patients with dyspnoea as the main symptom, assessed by prehospital emergency nurses- a retrospective observational study. *BMC Emerg Med*. 2020;20(1):67.
6. Prekker ME, Feemster LC, Hough CL, Carlbom D, Crothers K, Au DH, et al. The epidemiology and outcome of prehospital respiratory distress. *Acad Emerg Med*. 2014;21(5):543–50.
7. Kelly AM, Holdgate A, Keijzers G, Klim S, Graham CA, Craig S, et al. Epidemiology, prehospital care and outcomes of patients arriving by ambulance with dyspnoea: an observational study. *Scand J Trauma Resusc Emerg Med*. 2016;24(1):113.
8. Laribi S, Keijzers G, van Meer O, Klim S, Motiejunaite J, Kuan WS, et al. Epidemiology of patients presenting with dyspnea to emergency departments in Europe and the Asia-Pacific region. *Eur J Emerg Med*. 2019;26(5):345–9.
9. Ray P, Birolleau S, Lefort Y, Becquemin MH, Beigelman C, Isnard R, et al. Acute respiratory failure in the elderly: etiology, emergency diagnosis and prognosis. *Crit Care*. 2006;10(3):R82.
10. Schewe JC, Kappler J, Dovermann K, Graeff I, Ehrentraut SF, Heister U, et al. Diagnostic accuracy of physician-staffed emergency medical teams: a retrospective observational cohort study of prehospital versus hospital diagnosis in a 10-year interval. *Scand J Trauma Resusc Emerg Med*. 2019;27(1):36.
11. Peter J. Quality of emergency-medical diagnoses: A comparison of specialists and further education assistants of the anaesthesia [Medical doctoral thesis]: Friedrich-Alexander-Universität Erlangen-

Nürnberg (FAU), Germany; 2009.

12. Schröder H, Beckers SK, Ogrodzki K, Borgs C, Ziemann S, Follmann A, et al. Tele-EMS physicians improve life-threatening conditions during prehospital emergency missions. *Sci Rep*. 2021;11(1):14366.
13. Arntz HR, Klatt S, Stern R, Willich SN, Beneker J. Are emergency physicians' diagnoses accurate? *Anaesthesist*. 1996;45(2):163–70.
14. Heuer JF, Gruschka D, Crozier TA, Bleckmann A, Plock E, Moerer O, et al. Accuracy of prehospital diagnoses by emergency physicians: comparison with discharge diagnosis. *Eur J Emerg Med*. 2012;19(5):292–6.
15. Laursen CB, Sloth E, Lassen AT, Christensen R, Lambrechtsen J, Madsen PH, et al. Point-of-care ultrasonography in patients admitted with respiratory symptoms: a single-blind, randomised controlled trial. *Lancet Respir Med*. 2014;2(8):638–46.
16. Ahn JH, Jeon J, Toh HC, Noble VE, Kim JS, Kim YS, et al. SEARCH 8Es: A novel point of care ultrasound protocol for patients with chest pain, dyspnea or symptomatic hypotension in the emergency department. *PLoS One*. 2017;12(3):e0174581.
17. Buhumaid RE, St-Cyr Bourque J, Shokoohi H, Ma IWY, Longacre M, Liteplo AS. Integrating point-of-care ultrasound in the ED evaluation of patients presenting with chest pain and shortness of breath. *Am J Emerg Med*. 2019;37(2):298–303.
18. Hong W, Earnest A, Sultana P, Koh Z, Shahidah N, Ong ME. How accurate are vital signs in predicting clinical outcomes in critically ill emergency department patients. *Eur J Emerg Med*. 2013;20(1):27–32.
19. Kauppi W, Herlitz J, Karlsson T, Magnusson C, Palmér L, Axelsson C. Pre-hospital predictors of an adverse outcome among patients with dyspnoea as the main symptom assessed by pre-hospital emergency nurses - a retrospective observational study. *BMC Emerg Med*. 2020;20(1):89.
20. Burri E, Potocki M, Drexler B, Schuetz P, Mebazaa A, Ahlfeld U, et al. Value of arterial blood gas analysis in patients with acute dyspnea: an observational study. *Crit Care*. 2011;15(3):R145.
21. Gourhant V, Vuillot O, Claret PG, Lefebvre S, Schaub R, Flacher A, et al. Arterial pH selectively predicts critical care needs in emergency department obese patients with acute dyspnea: A prospective comparative study. *Am J Emerg Med*. 2019;37(1):67–72.
22. Bernhard M, Döll S, Kramer A, Weidhase L, Hartwig T, Petros S, et al. Elevated admission lactate levels in the emergency department are associated with increased 30-day mortality in non-trauma critically ill patients. *Scand J Trauma Resusc Emerg Med*. 2020;28(1):82.
23. Barfod C, Lundstrøm LH, Lauritzen MM, Danker JK, Sölétormos G, Forberg JL, et al. Peripheral venous lactate at admission is associated with in-hospital mortality, a prospective cohort study. *Acta Anaesthesiol Scand*. 2015;59(4):514–23.
24. Bou Chebl R, El Khuri C, Shami A, Rajha E, Faris N, Bachir R, et al. Serum lactate is an independent predictor of hospital mortality in critically ill patients in the emergency department: a retrospective study. *Scand J Trauma Resusc Emerg Med*. 2017;25(1):69.

Figures

Figure 1

Study population considering the inclusion and exclusion criteria * Number of PEMT encounters in which an EMS physician was at the scene (telemedical consultations were not considered); PEMT physician-staffed emergency medical team

Figure 2

Discharge diagnoses and diagnostic accuracy of the PEMT PEMT: physician-staffed emergency medical team; COPD: chronic obstructive pulmonary disease; ACS: acute coronary syndrome; NSTEMI: non-ST segment elevation ACS; STEMI: ST-elevation myocardial infarction; total of number of discharge diagnoses made: 793

Figure 3

What out-of-hospital diagnoses did the PEMTs suspect in cases of misdiagnosis? Shown are the PEMTs' incorrect suspected out-of-hospital diagnoses for the three most frequent discharge diagnoses; PEMT: physician-staffed emergency medical team; COPD: chronic obstructive pulmonary disease

Figure 4

Associations of initial examination findings and discharge diagnoses Binary logistic regression; only significant results are displayed, Odds ratios are shown in circles; * mean of the odds ratios (when identical auscultation findings in the out-of-hospital setting and in the emergency department yielded significant results); blue: increased probability of diagnosis; red: decreased probability of diagnosis. The following variables were reviewed for associations with discharge diagnoses: out-of-hospital findings: hypotension (systolic blood pressure < 100 mmHg), tachycardia (heart rate > 100/min), low oxygen saturation (peripheral oxygen saturation < 90%), tachypnea (respiratory rate $\geq$ 22/min), high temperature (body temperature $\geq$ 38 °C), body temperature $\leq$ 36 °C, reduced vigilance (Glasgow Coma Scale < 15), reported pain (numeric rating scale $\geq$ 1), crackles upon auscultation, wheezing upon auscultation, emergency department findings: crackles upon auscultation, wheezing upon auscultation, silent lung upon auscultation, and lower extremity edema. Detailed results of logistic regressions are shown in Additional file 3.

Figure 5

Hospital mortality and diagnostic error rates of PEMTs for the most frequent discharge diagnoses PEMT: physician-staffed emergency medical team; COPD: chronic obstructive pulmonary disease

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Additionalfiles.docx](#)
- [GraphicalAbstract.png](#)