Validity and risk factor analysis for helicopter emergency medical services (HEMS): The emergency call dispatch of Japanese air ambulances (Doctor-HeliTM)

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Research article

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Abstract

Background:

Some emergency departments use triage scales, such as the Canadian Triage and Acuity Scale and the JUST, to detect the status of life-threatening situations. However, these triage systems have not been used for aeromedical services in Japan. Therefore, we investigated these profiles and conducted a pilot study.

Method:

We retrospectively evaluated the helicopter emergency medical service cases from 1 April 2015 to 31 March 2020 at Gifu University Hospital using our mission record. In this study, we only evaluated cases that dealt with internal medicine. We excluded cases that were influenced by external factors such as trauma or cases that included hospital-to-hospital transportation, focusing only on prehospital care. We evaluated the validity of medical emergencies such as emergency interventions and the necessity of hospital admission. In addition, we evaluated the validity of the suggested diagnoses and the associated risk factors.

Result:

A total of 451 cases were suitable for inclusion in the study. In the analysis for all emergency calls, 235 (52.11%) needed emergency intervention and 300 (64.4%) required hospital admission. The suggested diagnosis was valid for 261 (57.87%) cases. After the first assessment by emergency medical technicians (EMTs), 75 cases were removed from the analysis.

Therefore, the results of the analysis for all emergency calls requiring emergency intervention were: 52.31%, need admission: 70.26%, and the suggested diagnosis was valid for 69.41% of cases. Results of a multivariate analysis of some key variables identified risk factors for emergency intervention, namely, age, under sports, and gasping. Hospital admission risk factors are being years old only. The suggested diagnosis was only valid in under sports situations.

In the first analysis, the risk factors for emergency intervention are years old, being male, under sports, and gasping, and for hospital admission they are years old, being male, detecting stroke symptoms, and disturbance of consciousness. The suggested diagnosis was only valid in under sports situations.

Conclusion:

There are some “second” keywords/phrases that predict medical emergencies. Therefore, the dispatch commander should gather these keyword/phrases to assess.

Backgropund

In medical diagnoses, a ‘killer word’ refers to words/phrases that predict life threatening and serious deceases, such as the sudden onset of chest pain, hemiplegia, unconsciousness, and collapsing.

In the emergency department, if the triage nurse/resident uses these words/phrases, these patients’ evaluations and treatments are prioritized compared to other patients in the emergency room. However, we do not decide the triage level depending only on the keyword. Rather, we determine the triage level using patient statements and their medical history. For example, there are tools for clinical decision making, such as the Canadian Triage and Acuity Scale (CTAS)[1)]. This scale is used for the first triage, which is decided based on situation and symptoms. Prehospital CTAS[2)] scores are used in North America. As another example, the JUST score[3)] has been used for transport decisions in stroke care. These scoring systems can help paramedics classify patients with suspected stroke.

Keyword responses are used for helicopter emergency medical service (HEMS) dispatch in Japan. This means that emergency medical communication centre operators dispatch HEMS according to these killer words. Therefore, we set up the key phrase tase killer word in the theory book for the operator. This system allows for rapid responses. However, the operator’s response has an increasing probability of failure. Speed of response is important, but the validity of dispatch should be improved because HEMS are scarce. However, there are few studies investigating the accuracy of HEMS calls. We explored some studies regarding trauma dispatch and identified their criteria for selection/triage.[4)5)] In addition, we identified their various dispatch criteria/strategy for specific statuses and diseases.[6)7)]

However, there are no studies that have systematically investigated the validity of dispatches. Therefore, we investigated this. In addition, by reviewing the records, we examined the trends of these predictive terms under specific situations and evaluated previous records to improve our research quality and prediction of keyword phrases. In the future, we expect to establish a commander-assist scale and systems such as the JUST score. We performed this study as a pilot study to use its results to inform future studies.

Materials And Methods

This study was a single-centre, retrospective observational study. We evaluated the operated HEMS (Doctor-Heli™) cases from 1 April 2015 to 31 March 2020 in Gifu University Hospital using our mission records from the national database registry project, J-HEMS. All mission data records are stored as part of the National Registry. Using these data records, we focused on the keywords and chest, chest and back pain, predicting cardiovascular diseases, sudden onset of hemiplegia predicting stroke, collapsing/unconsciousness predicting cardiopulmonary arrest, and any other internal medicine status to order HEMS cases, excluding cases with trauma and other external causes such as heat stroke. This means we focused on internal medicine emergency cases. In addition, we only focused on prehospital care and excluded transportation from hospital-to-hospital cases. We also excluded cases that were not suitable for analysis. For example, cases of patients with congenital diseases.

We evaluated the validity of medical emergencies such as emergency intervention and the necessity of hospital admission. In addition, we evaluated the validity of the suggested diagnoses. To examine the characteristics of each step, we evaluated the emergency validity in the first dispatch, and the second was examined after being assessed by an emergency medical technician (EMT), because if the patient status was not suitable for HEMS response, the HEMS order would be cancelled.

We evaluated validity from three viewpoints: needs emergency intervention, needs admission to hospital, and the validity of the suggested diagnoses. Then, we evaluated risk factors for each viewpoint by performing a multivariate logistic

regression analysis including the following predictor variables: phrases from the order summary (in particular, years of age, gender, situation, symptoms, and other characteristics) and dependent variables included: needs emergency intervention, hospital admission, and validity of the suggested diagnoses.

Doctor-Heli™ in JAPAN

In Japan, HEMS, called Doctor-Heli™, is organized by the government. Generally,

each prefectural government body organizes and financially manages the HEMS while being supported by the national government. This means that the public government takes responsibility for this air ambulance system.

However, the actual operation of the HEMS is assigned to each hospital. At the end of 2018, 43 public bodies organized HEMS, and 53 aircrafts/helicopters were in use in Japan. Gifu University Hospital is one of these assigned hospitals. Their HEMS covers Gifu prefecture and some parts of neighboring prefectures. The HEMS operation started in February 2011, and 4252 operations were performed until 31 March 2020. Annually, approximately 500–600 operations are performed at this hospital; approximately 50% of the operations are for prehospital care, approximately 40% are transported to advanced care, and approximately 10% are cancelled. In Japan, the patient and their family cannot directly call Doctor-Heli™.

When emergency medical communication centres receive emergency calls, if the operator deems it necessary to call Doctor-hell™, the dispatch commander orders a Doctor-Heli™ mission. This operator is a staff member of the fire department but is not entirely trained systematically.

Each operating hospital has a set call strategy for orders. The keyword list in Gifu University Hospital and the prefecture is shown in Table 1. Each organizing body/facility has a keyword list. Keywords have similarities but there are differences depending on their situation.

Statistical analysis

Fundamental statistics were obtained from observation data, which were calculated using Microsoft Excel for MAC ver.16.45. Multivariate analysis was performed using SPSS (IBM).

Ethical considerations

This study was performed as a part of the national database registry project, J-HEMS, using the project's data and Gifu University Hospital's medical records. This study was approved by the institutional ethical review board of Gifu University/Gifu University Hospital. Informed consent of the recorded patient was obtained by opt-out on the website. Those who rejected were excluded. In addition, we were given permission to use institutional data from the Japan Society for Aeromedical services.

Results

From 1 April 2015 to 31 March 2020 Gifu University Hospital had 2387 cases. We excluded 873 cases due to transport between hospitals for advanced medical care; 1043 cases due to trauma, other external factor diseases, and mass casualty incidents; and 19 cases because we judged them as being unsuitable for analysis, such as cases with congenital diseases affecting decision making and data insufficiency. Details are shown in Fig. 1. As a result, 451 cases were included for emergency call analysis, and 376 cases were included for emergency call analysis. Demographic data are shown in Fig. 1.

1: Analysis of validity for HEMS orders

We evaluated validity from three viewpoints: needs emergency intervention, needs admission to hospital, and the validity of the suggested diagnoses. Details are shown in Table 2. a) analysis for Emergency call (451 orders)

In the analysis of all emergency calls, 235 (52.11%) needed emergency intervention, 300 (64.4%) needed admission, and the suggested diagnosis was valid for 261 (57.87%) cases.

When we evaluated the suggested disease group, in the analysis of suggested cardiovascular diseases (222 cases), 102 (45.95%) needed emergency intervention, 137 (61.71%) needed admission, and the suggested diagnosis was valid for 124 (55.86%) cases. For suggested strokes (135 cases), 82 (60.74%) needed emergency intervention, 98 (72.59%) needed hospital admission, and the suggested diagnosis was valid for 74 (54.86%) cases. For suggested CPA (54 cases), 41(75.93%) needed emergency intervention, 44(81.48%) needed hospital admission, and the suggested diagnosis was valid for 43 (79.63%) cases.

For other suggested internal emergencies (40 cases), 10(25%) needed emergency intervention, 21 (61.71%) needed hospital admission, and the suggested diagnosis was valid for 20 (50.00%) cases.

2: Analysis after the first assessment by an EMT

After the first assessment by an EMT, 75 cases were removed from the analysis. Subsequently, we conducted a second analysis. Details are shown in Table 2.

The analysis results show that for all emergency calls, 52.31% required emergency intervention, 70.26% needed hospital admission, and the suggested diagnosis was valid for 69.41% of cases. When we evaluated the suggested disease group, cases of suggested cardiovascular diseases (195 cases), 52.31%

needed emergency intervention, 70.26% needed hospital admission, and the suggested diagnosis was valid for 63.59% of cases. For suggested strokes (108 cases), 76.85% needed emergency intervention, 91.67% needed hospital admission, and the suggested diagnosis was valid for 74 (69.44%) cases.

For suggested CPA (45 cases), 91.11% needed emergency intervention, 97.78% needed hospital admission, and the suggested diagnosis was valid for 43 (95.56%) cases. For other suggested internal emergencies (28 cases), 35.71% needed emergency intervention, 75.00% needed admission, and the suggested diagnosis was valid for 71.43% of cases.

3: List of initial diagnoses in hospital

The list of suggested cardiovascular disease cases and the results are presented in Table 3.

3a) Cardiovascular diseases

In the analysis of emergency calls, 55.9% of all cases were cardiovascular diseases. ACS was diagnosed in 51 cases, 23.0% of all suggested cases, and 40% of diagnosed cardiovascular cases. In addition, 27 cases (12.7% of all suggested, 21.7% of all diagnosed cases) were aortic diseases.

In the analysis after the first assessment by an EMT, 63.6% were cardiovascular diseases. ACS accounted for 26.2% of all suggested cases, and 13.8% of all suggested cases were aortic diseases.

3b) Stroke

In the analysis for emergency calls, 55.6% of all suggested cases were strokes. Intracranial hemorrhage (ICH) occurred in 30 cases, 22.2% of all suggested cases, and 40% were diagnosed stroke cases. In addition, 29 cases (21.4% of all suggested, 38.6% of all diagnosed cases) were ischemic stroke, and 13 cases (9.6% of all suggested, 17.3% of all diagnosed cases) were subarachnoid hemorrhages (SAHs). In the analysis after the first assessment by an EMT, 69.4% were stroke cases. ICH accounted for 27.8% of all suggested cases. In addition, 26.8% of all suggested cases were ischemic strokes (12% of all diagnosed cases) and were SAHs.

4. Risk analysis

In this study, we analyzed the factors that affect clinical decisions and outcomes. To

reveal which phrases correspond to which complaints/symptoms, affecting clinical results such as emergency interventions, we analyzed various phrases from medical and operation records.

We performed a multivariate logistic regression analysis which included predictor variables: some phrases from order summaries (in particular, age, gender, situation, symptoms, and other characteristics), and dependent variables: needing emergency intervention, hospital admission, and validity of the suggested diagnoses.

In the analysis of the emergency calls, the risk factors for emergency intervention were years old, the situation was under sports, and the symptom was gasping. For hospital admission the risk factor was only years old. Validity for suggested diagnosis was only situations: under sports.

In the analysis of the first assessment by an EMT, the risk factors for emergency intervention were years old, being male, situation: under sports, and gasping for air symptoms. For hospital admission the risk factors were years old, being male, having stroke symptoms or experiencing disturbance of consciousness. For validity of suggested diagnoses the risk factors was only situations under sports. The details are shown in Table 4.

We also analyzed suggested disease groups for cardiovascular diseases and strokes. a) Analysis for cardiovascular diseases

In the analysis of emergency calls, the risk factors for emergency intervention were years old and situation: under sports, for hospital admission they were only years old and being male, and for validity of suggested diagnoses the only risk factor was only situations: under sports only.

In the second analysis, the risk factors for emergency intervention were years old, situation: under sports, for hospital admission they were years old and being male, and for validity of suggested diagnoses the only risk factor was situations: under sports. Details of the analysis are shown in Supplementary Table 1.

b) Analysis for stroke

In the analysis of emergency calls, the risk factors for emergency intervention were gasping for air, and downgrade factors were disturbance of consciousness and an emergency call from a family member. The risk for hospital admission was only gasping for air. The validity of the suggested diagnosis was also only gasping for air. The downgrade factor for validity of the suggested diagnoses was only a disturbance of consciousness.

After the first assessment by an EMT, there were no risk factors for emergency intervention and hospital admission. The downgrade factor for validity of the suggested diagnoses was only a disturbance of consciousness. Details of the analysis are shown in Supplementary Table 2.

Discussion

In Japan, the number of emergency calls and HEMS dispatch continue to increase.8) This means that HEMS order numbers are likely to increase. However, it is quite difficult to increase the number of HEMS because of its very high cost. In addition, keyword responses are consulted when HEMS are dispatched in Japan, as the operator in emergency medical communication centres' head office or crew leader order HEMS referring to these killer words. Therefore, we set up the key phrase tase killer word in the theory book for the dispatch commander. This system can ensure rapid responses. However, this system can overestimate and increase the number of unnecessary cases. Therefore, we must develop the theory to guide decisions regarding which cases are high priorities.

First, we discuss the validity of the HEMS dispatch. It is difficult to define validity. In this study, we set admission as the relation between suggested diagnosis and initial diagnosis in the hospital, and necessity of admission as ‘correct dispatch’. Regarding objectives for HEMS, we provide medical and definitive care as soon as possible. Therefore, we evaluated possible factors of emergency interventions. Referring to previous studies, there are no studies evaluating the validity of dispatch. However, we found symptom-based research on emergency phone protocol. Ellensen et al.[9)] investigated emergency medical communication centres’ dispatch resources and transport for stroke patients in Norway. According to their results, the validity of suspected stroke was only 45.6% from the emergency call protocol. Burman[10)] investigated data on the epidemiology of acute chest pain outside the hospitals in Norway. They highlighted that NACA-scores indicated that 26% of the patients were in a life-threatening medical situation. Judging from these studies, our analysis of the validity of using keywords when dispatching HEMS is warranted.

However, we believe this validity is insufficient. HEMS are scarce resources. Therefore, we performed a multivariate analysis with predictor variables being the phrases from order summaries (in particular, age, gender, situation, symptoms, and other characteristics). Dependent variables were the need for emergency intervention, hospital admission, and the validity of the suggested diagnosis. As a result, some keywords were identified as predicting factors.

This result is not only for the overview analysis, but also for the disease group analysis. Referring to previous studies, Munro[11)] investigated the improvement accuracy of HEMS intervention using an algorithm approach and concluded that when aided by a bespoke algorithm the accuracy of HEMS dispatch improved.

Additionally, a similar approach is suggested for each symptom and disease group analysis. For example, Pedersen et al.[12)] investigated chest pain in acute ambulance transport in the Central Denmark Region, and presented its profile and the factors influencing a patient being discharged without a severe cardiac diagnosis and surviving 30 days after a chest pain event. Ellensen et al.[9)] investigated emergency medical communication centres’ dispatch resources and transport for stroke patients in Norway, and highlighted possible factors associated with stroke prediction. In our study, a similar trend was found. There are

possible factors associated with stroke prediction, for example, in the analysis being an elderly male and participating in sports were the predictive factors for emergency intervention.

From our results, risk factors and downgrading factors from the multivariate analysis were general and were not specific to a patient’s medical history. Therefore, it is not difficult for the communication centre operators to gather these medical histories if these risk factors are listed. In fact, Grusd et al.[13)] attempted to analyse whether dispatch triage tools could reliably identify patients who only required transport by analyzing electronic and paper records of an ambulance service from four random days in 2012. They

concluded that the Norwegian index was able to predict which patients do not need immediate medical treatment. This study explains ‘downgrade’ factors but using predicting systems could be beneficial.

Based on the findings of Grusd et al.[13)], we suggest the following steps.

1. HEMS should be ordered based on the keywords listed in the guidelines.
2. Helicopters take off.
3. HEMS personnel stay on the line while the emergency medical communication centre operators gather a second keyword.
4. HEMS operators receive this information, and then score and grade the case to ensure there is no overlapping.

This system could enhance to speed and decide the priority of each case and should be investigated in future studies. The final goal should be to establish a scoring tool such as the EDACS in ACS[14)] to improve HEMS in Japan.

Limitation Of This Study

This single-centre study focused only on one prefecture in Japan. Therefore, the

results of this study only reflect the trend of this prefecture, and do not reflect the national Japanese trend. In addition, we only analyzed the order records of one hospital whose information on emergency calls and activities we had access to. Therefore, this information is limited and cannot provide generalizable results. Furthermore, we did not focus on ‘underestimation’ cases. This means that this study did not include the cases that were not called in, hence we could not determine the validity of cancelled orders.

Conclusion

There are some keyword/phrases that predict medical emergencies. Thus, HEMS dispatch commanders should gather these keyword/phrases. However, we found some trends in HEMS orders.

It is necessary for us to perform further analyses using a national database and to establish a set of guidelines to enhance the validity of clinical decision making.

Declarations

Ethics approval and consent to participate

This study was performed as a part of National database registry project called J-HEMS, using this data and using medical record in our facility. This study was approved by institutional ethical review board in

Gifu University/Gifu University Hospital. In addition, we are allowed to use our institutional data by Japan Society for Aeromedical services.

Informed consent of the recorded patient was obtained by opt-out on the website. Those who rejected were excluded.

Consent for publication

Informed consent of the recorded patient was obtained by opt-out on the website. Those who rejected were excluded.

Availability of data and materials

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

Competing interests

The authors declares that they have no competing interests.

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Authors' contributions

NY: design of the work, data analysis and have drafted manuscript,

YK: design of the work and data analysis.

TY: design of the work, data analysis and revised works.

SN: design of the work, data analysis and revised works.

HO: supervised and revised works.

SO: supervised and revised works.

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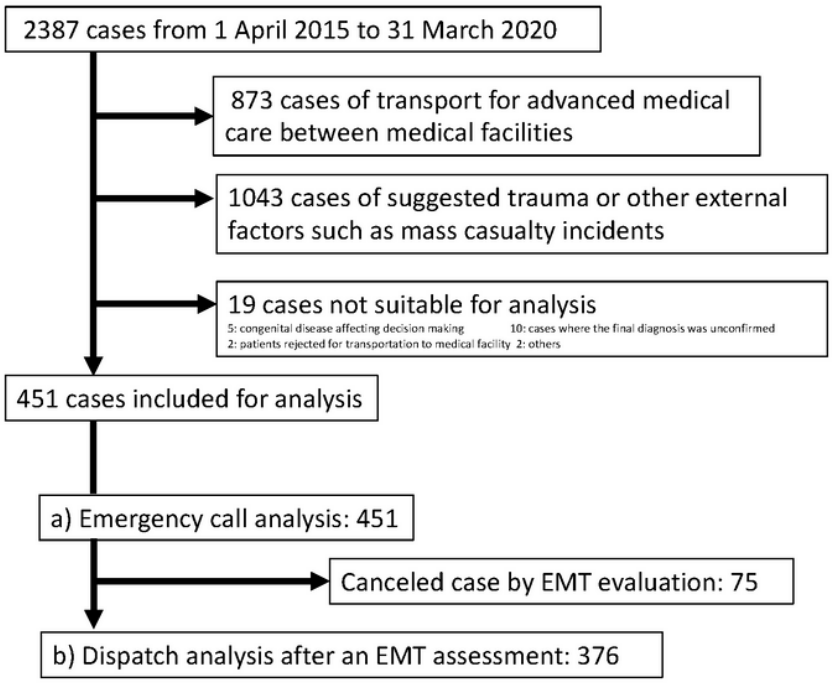
Tables

Due to technical limitations, table 1, 2, 3, 4 is only available as a download in the Supplemental Files section.

Figures



Emergency call	
Total cases	451
Years of age	68.15 ± 16.85
	(0-96)
male:female	303:147
unknown	(1 missing data)
Suggested diseases/status	
Cardiovascular	222
Stroke	135
CPA	54
Other diseases	40
After EMT assessment	
Total cases	376
Years of age	68.89 ± 15.78
	(0-96)
male:female	253:123
Suggested diseases/status	
Cardiovascular	195
Stroke	108
CPA	45
Other diseases	28

Figure 1

Data collection flow and geographic data.

Supplementary Files

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

- table1keywordlist.pdf

- renamedfbd6d.pdf
- table3diagnosis.pdf
- table4maiti.pdf
- suppltable1malitiheart.pdf
- suppltable2maltistroke.pdf