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Criteria-based dispatch of emergency medical services in non–traumatic subarachnoid haemorrhage

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ABSTRACT

Introduction: Timely admission to a facility capable of providing highly specialised treatment is key in patients with spontaneous subarachnoid haemorrhage. We aimed to determine the time elapsed from the initial emergency telephone call to arrival at a neurosurgical department. Also, we aimed to determine the ambulance dispatch criteria used and the activated prehospital responses.

Methods: This was a retrospective study. Patients admitted in the Capital Region of Denmark within a 3.5-year period were identified in the Danish National Patient Register. Data were extracted from medical records and from automated telephone logs at the Emergency Medical Dispatch Centre.

Results: Time intervals were available in 124 out of 262 patients and ambulance dispatch criteria in 98 patients. The median time from call to neurosurgical admission was 207.5 minutes. The dispatch criterion sudden severe headache had a sensitivity of 17.4%. An ambulance with lights and sirens was dispatched to 77% of patients and 28% were brought directly to a hospital with neurosurgical facilities.

Conclusions: The median time from emergency call to neurosurgical admission was 3.5 hours. No single dispatch criterion detected the condition with an acceptable sensitivity. A high proportion of patients received an ambulance with lights and sirens, but more than two out of three were not initially brought to a hospital with neurosurgical facilities.

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Non-traumatic subarachnoid haemorrhage (SAH) has a 30-day mortality of 35% [1]. Early clinical suspicion and timely expert treatment are critical [2]. A study from 2007-8 found a median time from symptom onset to neurosurgical admission of 5.5 hours in the Capital Region of Denmark [3], but on 1 May 2011 the prehospital system was reorganised. Health-related emergencies are now handled by healthcare professionals at an

emergency medical dispatch centre (EMDC). An electronic decision support system (DSS) using criteria-based dispatch was also introduced. In emergencies, citizens now call "1-1-2" to be triaged to the most appropriate prehospital response. As from 1 January 2014, out-of-hours non-urgent medical advice calls were no longer managed by on-call general practitioners, but by healthcare professionals at a dedicated telephone line of the EMDC named "1813". However, telephone triage is a difficult task, and the choice of words and phrases used by the caller are critical for correct dispatch of emergency medical services [4]. Raising the suspicion of stroke already during the telephone call is vital to reduce ambulance on-scene time and transportation time, choose the right receiving hospital and reduce time spent in the emergency room [4]. The effect of a criteria-based dispatch system staffed by healthcare professionals on the time to neurosurgical care in patients with SAH has never been investigated.

We aimed, firstly, to determine the time interval between emergency telephone calls to the EMDC and arrival of the patients at a neurosurgical department. Secondly, we aimed to determine the type of dispatch criteria used in patients with SAH, the proportion of patients who received an ambulance with lights and sirens, and the proportion of patients brought directly to a hospital with neurosurgical facilities.

METHODS

Design and setting: This retrospective study was conducted in the Capital Region of Denmark. The region has one hospital with neurosurgical facilities and nine referring hospitals. The EMDC is the point of contact in case of medical emergencies ("1-1-2"). During the study period, the EMDC also became the point of contact when out-of-hours non-urgent medical advice was needed ("1813"). Dispatchers are medically trained. At "1-1-2", they are aided by an electronic DSS [5]. Dispatchers at ´1813´ can choose to use the same electronic DSS and can convert a non-urgent 1813-call into an emergency 1-1-2-call.

Participants: The cohort is described elsewhere [6]. Patients were aged 18 years or more, had a Danish civil registration number (CPR) [7] and had a discharge diagnosis of SAH (International Classification of Diseases, version 10; codes I60.0-I60.9) in the Danish National Patient Register [8]. Diagnoses were validated by medical record review. Their first admission was to one of the hospitals in the Capital Region of Denmark between 1 May 2011 and 31 December 2014. We included aneurysmal and non-aneurysmal non-traumatic SAH.

Data sources and variables: Using medical records, we extracted the date and time of admission to the first hospital department (hereafter: referring department) and to the neurosurgical department. Using the CPR number, we identified calls to the EMDC within 28 days prior to admission to the referring department. We extracted the time of the call, the dispatch criterion, the activated response and the number of repeated calls. Due to system changes, time stamps and admission data were obtained for the entire study period for calls to the emergency number "1-1-2" and from 1 January 2014 for the non-urgent medical advice number "1813". Data from the DSS were available only for the emergency number "1-1-2" and only until 31 December 2013.

To calculate predictive values of the dispatch criteria, we extracted the total number of calls to the emergency number "1-1-2" and the total number of calls to "1-1-2" in which the symptom-specific dispatch criteria were used.

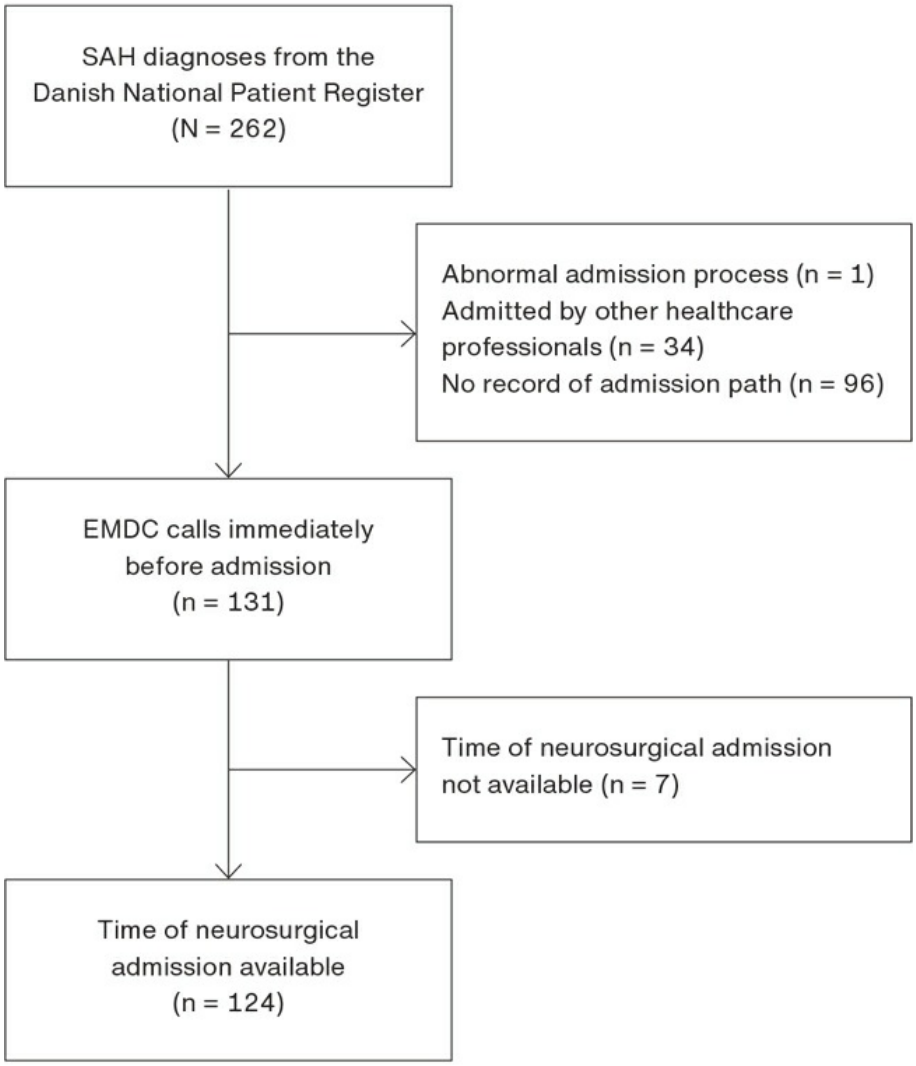
Analyses: Continuous variables were reported as medians with interquartile range (IQR) and categorical variables as frequencies and percentages. Sensitivity, specificity, positive predictive value and negative predictive value were reported with 95% confidence intervals (95% CI). Predictors for direct admission to a hospital with neurosurgical facilities were assessed by odds ratio (OR) from logistic regression. Statistical analyses were performed in SAS version 9.4.

Trial registration: The study was approved by the Danish Data Protection Agency and the Danish Health and Medicines Authority. Approval by the Danish Committee System on Health Research Ethics was waived. Finally, the study was registered with clinicaltrials.gov (NCT03786068).

RESULTS

The original cohort consisted of 537 patients, of whom 262 were eligible for inclusion in this study. Among these, 131 had contacted the EMDC ("1-1-2" or "1813"), and in 124 patients the neurosurgical admission time was available (**Figure 1**). A total of 65% were women and the median age was 58.0 years (IQR: 48.0-67.0). The time interval between call and arrival at the referring department was 51.0 minutes (IQR: 39.0-60.0) and the time interval from call to neurosurgical admission was 207.5 minutes (IQR: 147.0-304.5). Among the 96 patients with no data on admission path, six had called the EMDC within 28 days without being admitted; and 15, 22, 25, and 34 of the patients had been admitted in the years 2011, 2012, 2013, and 2014, respectively. Three of the 34 patients admitted by other healthcare professionals and two of the 131 patients admitted via the EMDC had called within 28 days without being admitted.

FIGURE 1 Study inclusion of patients with spontaneous subarachnoid haemorrhage.



EMDC = emergency medical dispatch centre; SAH = non-traumatic subarachnoid haemorrhage.

Symptoms

DSS data were available in 98 SAH patients who had called the emergency number "1-1-2" (**Table 1**). Hence, in our study cohort of 282,898 calls to "1-1-2", the prevalence of SAH was 0.035%. Sudden severe headache was the most frequently used symptom-specific dispatch criterion. It was used in 17 of 98 patients with SAH and 207 of 282,800 without SAH, yielding a sensitivity of 17.4% and a positive predictive value of 7.6% (**Table 2**).

TABLE 1 Main chapters of a decision support system used in response to emergency calls regarding patients with non-traumatic subarachnoid haemorrhage (N = 98). Ordered by frequency.

Main chapter	Calls, n (%)
Unclear problem	27 (27.6)
Headache	24 (24.5)
Altered consciousness, paralyses or dizziness	18 (18.4)
Unconscious adult	15 (15.3)
Chest pain, cardiac condition	2 (2.0)
Accident	2 (2.0)
Seizure	2 (2.0)
Traffic accident	2 (2.0)
Diabetes	1 (1.0)
Abdominal or back pain	1 (1.0)
Alcohol, intoxication or overdose	1 (1.0)
Minor injury	1 (1.0)
Breathing difficulty	1 (1.0)
Non-traumatic haemorrhage	1 (1.0)

TABLE 2 Order of the most frequently recorded symptom-specific dispatch criteria in emergency calls regarding patients with non-traumatic subarachnoid haemorrhage. Finally, "Other" is added.

Decision support system chapter: Symptom-specific dispatch criterion	SAH patients, n (n_{SAH} = 98)	Total, n (%) (N = 282,898)	SE, % (95% CI)	SP, % (95% CI)	PPV, % (95% CI)	NPV, % (95% CI)
Headache:						
Sudden, intense and different headache, thunderclap headache, severely affected	17	224 (0.08)	17.4 (10.4-26.3)	99.9 (99.9-100)	7.6 (4.5-11.9)	99.9 (99.9-100)
Altered level of consciousness, paralysis or dizziness:						
Suspicion of stroke, sudden facial paralysis, reduced limb strength or speech difficulty	13	5,755 (0.02)	13.3 (7.3-21.6)	98.0 (97.9-98.0)	0.2 (0.1-0.4)	99.9 (99.9-100)
Unconscious adult:						
Not breathing normally	7	3,865 (0.01)	7.1 (2.9-14.2)	98.6 (98.6-98.7)	0.2 (0.1-0.4)	99.9 (99.9-100)
Breathing normally	7	4,489 (0.02)	7.1 (2.9-14.2)	98.4 (98.4-98.5)	0.2 (0.0-0.4)	99.9 (99.9-100)
Headache:						
Increasingly confused, possible problem with speech	5	231 (0.08)	5.1 (1.7-11.5)	99.9 (99.9-100)	2.2 (0.7-5.0)	99.9 (99.9-100)
Other:						
31 symptoms pooled	49	-	N/A	N/A	N/A	N/A

CI = confidence interval; N/A = no answer; NPV = negative predictive value; PPV = positive predictive value; SAH = non-traumatic subarachnoid haemorrhage; SE = sensitivity; SP = specificity.

Dispatch criteria

An ambulance with lights and sirens was dispatched to 76.6% (95% CI: 69.2-84.1, n = 95) of patients, an ambulance without lights and sirens to 19.4% (95% CI: 12.4-26.3, n = 24), and 2.4% (95% CI: 0.0-5.1, n = 3) were advised to see an out-of-hours general practitioner who subsequently admitted them (missing: n = 2). Direct admission to a hospital with neurosurgical facilities (27.7%, 95% CI: 19.7-35.8, n = 33) resulted in a time interval from admission to the referring department to neurosurgical admission of 85.0 minutes (IQR: 73.0-111.0). For the 72.3% (95% CI: 64.2-80.3, n = 86) of patients initially admitted to a non-neurosurgical hospital, the time interval was 186.5 minutes (IQR: 128.0-328.0) (missing: n = 5). In patients who were dispatched an ambulance with lights and sirens, females were more likely to be admitted directly to a hospital with neurosurgical facilities than men were (OR = 2.99, 95% CI: 1.13-7.93, p = 0.027), whereas no significant age difference was found (OR = 0.91, 95% CI: 0.67-1.24, p = 0.55).

DISCUSSION

The key finding of this study was a median time interval from emergency call to neurosurgical admission of 207.5 minutes or 3.5 hours. The symptom-specific dispatch criterion most frequently used was sudden severe headache followed by change in the level of consciousness, but the sensitivity and positive predictive value of any single symptom was low. However, the system overall had a high ability to detect the urgency of the condition measured as the proportion of SAH patients assigned an emergency ambulance. Less than thirty percent were initially brought to a hospital with neurosurgical facilities.

The time to highly specialised care is crucial for patient outcome [2]; this is largely due to the 12-13% risk of re-bleeding within the first 24 hours [9, 10]. Before the reorganisation of the emergency medical service, a time interval of 60 minutes from symptom onset to admission to the referring department was reported, including a patient delay of approximately 20 minutes [3]. Thus, the median time from call to neurosurgical admission was approximately five hours. In comparison, we found a time interval of only 3.5 hours. However, the time interval between emergency call and admission to the referring department was comparable in the two studies

(approximately 40 minutes versus 51 minutes). Thus, it seems that less time was spent in hospital and on interhospital transfer, but the majority of pre-neurosurgical time remained related to these phases despite short distances in the region. Pre-arrival notification of ambulance crews and receiving hospitals is vital for treatment to be initiated early [11]. Therefore, recognition of a life-threatening condition during the emergency call is key. In our study, 77% of patients received an ambulance with lights and sirens, which is satisfactory given the wide variety of symptoms with which these patients presented. The remaining 23% did not receive an ambulance with lights and sirens, which may indicate that the urgency of the condition was missed. Very few patients had called the EMDC within 28 days without being admitted.

Several studies have reported a misdiagnosis frequency of SAH in the 5-19% range in emergency department settings [12, 13]. Whereas several symptom score systems have been designed to assist in emergency department recognition of SAH, so far, none have been designed to recognise patients with SAH during telephone calls. The dispatcher has only limited information and no visual cues in this setting. In this first analysis of the dispatch-criteria used in patients with SAH, the DSS chapter 'unclear problem' was used in 27% of calls. In comparison, it is used in 18% of emergency calls in general [14]. We found sudden severe headache, symptoms resembling ischaemic stroke and unconsciousness to be the most frequently used symptom-specific criteria. Still, these criteria had low sensitivities and positive predictive values. Considering the low sensitivities, the variety of dispatch criteria and the low incidence of SAH, EMDC dispatchers may need additional support in their decision-making process if a pre-arrival notification of suspected SAH is to be sent to the ambulance crew.

A total of 72% of patients with SAH were initially brought to a hospital without neurosurgical facilities and required secondary transfer. Interestingly, we found women to have a higher chance of being admitted directly to a hospital with neurosurgical facilities. It remains to be investigated if this is related to a difference in the severity of symptoms or an increased awareness of the risk of SAH in females. It is debated if SAH patients benefit from direct admission to a hospital with neurosurgical expertise or if initial stabilisation at a primary stroke centre is equally safe [15]. Direct admission to a highly specialised centre has been found to yield a shorter ICU stay, a lower risk of vasospasm and a better neurological outcome [16]. The authors concluded that this may be explained by the difference in time to final treatment, different neuroprotective treatments given at the primary stroke centre and neuro-ICUs and the transfer process itself. Similar results were reported in a study comprising 1,134 patients where patients admitted directly to a specialised centre had 1.8 times greater odds of survival than those undergoing secondary transfer, despite being in a poorer neurological state at the time of admission [17]. Other studies, however, found no association between transfer time and the frequency of complications or outcomes [18]. Some argue that patients with severe symptoms should be transported directly to a hospital with neurosurgical facilities, whereas patients with milder symptoms may initially be transported to a local hospital for diagnostic workup and stabilisation [19]. Our study was conducted primarily in an urban area with short transport distances. In addition, some differences exist in the prehospital organisation between regions, which may limit the external validity of this study.

Strengths and limitations: The linkage of individual-level data from the Danish National Patient Register, the EMDC and medical records is a strength. Also, having validated every diagnosis by medical record review increased the data quality. However, our data did not allow us to report how patients who were not admitted via the EMDC reached hospital. Thirty-four of these patients were admitted by general practitioners why their symptoms may have been milder. In another 96 patients, no data on path of admission were available and it remains unknown why this piece of information was missing more often in more recent years. Whether these patients share certain characteristics is important to determine in future studies. It must be acknowledged that our results are based on a selected population. It is likely that we have included mainly patients with more severe symptoms. Consequently, the time interval from emergency call to neurosurgical admission may be

biased towards a faster admission than for patients with less severe symptoms. Also, symptom-based dispatch criteria could be gathered only from "1-1-2", which may reflect the presentations of the most severely ill patients. Another limitation is the lack of information on the severity of the haemorrhages, but consistent data on this were not available.

CONCLUSIONS

The time interval from emergency call to neurosurgical admission was 207.5 minutes. No single symptom was able to detect SAH with an acceptable PPV and sensitivity. Despite the wide variations in symptoms, an ambulance with lights and sirens was dispatched to 77% of patients. A total of 72% percent of SAH patients were initially brought to a hospital without neurosurgical facilities and needed a secondary transfer. Health service improvements should focus on increasing the SAH population's use of the EMDC, improving the DSS algorithm and notifying EMS personnel of the suspicion of SAH.

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Conflicts of interest Potential conflicts of interest have been declared. Disclosure forms provided by the authors are available with the article at ugeskriftet.dk/dmj

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