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The last decade of symptom-oriented research in emergency medicine: triage, work-up, and disposition

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Summary

As a result of the ever-increasing use of imaging and clinical chemistry, symptom-oriented research has lost ground in many areas of clinical medicine. In emergency medicine, the importance of symptom-oriented research is obvious, as the three major tasks (triage, work-up and disposition) are still under-investigated. Scientific progress is closely linked to the analysis of readily available information, such as the patients' symptoms.

A decade ago, there were more questions than answers. Therefore, we describe the state of the evidence and the importance of symptoms for decisions at triage, during work-up and for disposition. Recent advances in each field focusing on symptoms as predictors of outcome and/or diagnosis are shown. Finally, future directions of research regarding novel triage tools, efficient work-up and evidence-based disposition are discussed. Symptom-oriented research has been a driver for medical progress for centuries, and re-focusing on patient-centred clinical research will strengthen this field in the future in order to support smarter medicine.

Keywords: *symptom-oriented research, chief complaint, presenting symptom, high-risk situation, nonspecific complaints, nonspecific symptom, frailty, triage, work-up, disposition, smarter medicine, emergency medicine, outcome, mortality*

Introduction

Symptom-oriented research has become the domain of emergency medicine research, as most other specialities have strongly focused diagnostic and prognostic research on individual disease entities, such as asthma, or coronary heart disease, using new methods, including genetics or nuclear medicine [1, 2]. Furthermore, owing to the ever-increasing use of imaging and clinical chemistry, symptom-oriented research has lost ground in many areas of clinical medicine. In the last 20 years, the renowned *New England Journal of Medicine* has published only one article using "symptom" in the title, namely "throat clearing" as a novel asthma symptom in children [3]. Its counterpart, the *Lancet*, has published three articles, two letters on "constipation", and recently one on the safety of digital symptom checkers [4]. As symptom-oriented research was a major driving force in clinical medicine for centuries [5], it seems surprising that the lack of knowledge on the prevalence of underlying conditions and outcomes associated with presenting symptoms has not sparked more scientific interest in recent years. However, this deficit was sensed by the US National Institutes of Health (NIH) and the insufficient investment in this type of research was acknowledged [6, 7].

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Importance of symptom-oriented research in emergency medicine

Symptom-oriented research has the potential not only to improve the diagnostic process, but also to provide a prognosis at the earliest timepoint. Emergency medicine is a relatively new field of research covering the earliest phase of acute care and focusing on triage, initial work-up regarding *clinical* diagnoses, disposition and the early identification of risk factors for serious outcomes such as mortality or institutionalisation. In emergency medicine, patient influx is unpredictable and the risk of short-term morbidity and mortality is considerable. Therefore, risk stratification, for example by triage at presentation, is of pivotal importance. Symptoms, signs and vital parameters are the cornerstones of this process. Vital signs have been extensively studied, whereas the prognostic impact of symptoms has not been well described in emergency medicine.

In order to achieve scientific progress in this medically and economically important field, certain deficits have to be named and key facts acknowledged: First, avoidable mortality should be reduced by means of improving triage processes, as unexpected mortality has been shown to occur after discharge from the emergency department (ED) [8]. Second, unnecessary hospitalisation should be reduced by improving disposition processes, as hospitalisation is one of the major drivers of rising expenses in this field [9]. Third, waste of resources should be tackled by smarter medicine, namely sound and early clinical diagnoses without over-diagnosis and over-use of imaging and clinical chemistry, as the increasing use of imaging may only raise costs, but not change outcomes [10]. Fourth, deleterious outcomes and institutionalisation should be avoided in old-

er patients by early detection of frailty and perilous combinations of vital parameters, symptoms and reduced activities of daily life. These deficits have to be interpreted from the perspective that in highly developed countries the majority of acutely and severely sick patients present to EDs. We will therefore focus on these challenges and give an overview of the improvements during the last decade.

In Switzerland, decisions in EDs affect over 2 million patients, the average cost being CHF 600 in ambulatory, and CHF 16,600 in hospitalised patients (own data). Emergency medicine and primary care have many challenges in common. The common issues in symptom-oriented research and diagnostic strategies in these two specialties are similar [11], but the most frequent symptoms vary considerably between primary care and emergency medicine [12]. Triage is not a major topic in primary care, as short-term mortality and crowding (higher number of patients relative to available resources) are not as prominent as in emergency medicine, and ambulance referral with its high burden of morbidity and mortality is not an issue [13].

Advances due to symptom-oriented research at triage

A decade ago, knowledge on triage was limited to predictive validity and reliability; the issue that triage categories are imprecise and largely overlapping was not even recognised as a problem [14]. Evidence on disposition processes was scant [15] and research on the detection of frailty in the ED consisted of a single publication [16].

At that time, the two most widely used triage tools were the Manchester Triage System (MTS) in Europe and the Emergency Severity Index (ESI) in the USA. In 1966 the first original article on triage was published [17], but before 1999, no benefit from nurse triage was ever demonstrated [18]. In 2007 nurse triage was firmly established, and its efficiency and accuracy proven [19]. Among the the first tools, MTS was introduced in 1996, with flow charts for different typical presentations and key indicators. Interestingly, the two main triage tools have followed opposite approaches to evaluating certain symptoms. The MTS assigned patients with chest pain to different risk strata, whereas the ESI generally endorsed the second highest risk category for all patients with chest pain. The consequence of these different triage algorithms was that chest pain patients were immediately admitted to the ED for ECG monitoring according to the ESI [20, 21], but might have been triaged to the waiting room according to the MTS [22]. This used to be (and remains) a disturbing fact, but it is obviously a direct consequence of the lack of data on presenting symptoms. In the last decade, several studies have produced surprising evidence: the typical precordial chest pain in myocardial infarction, described centuries ago, did not have high accuracy or discrimination regarding diagnosis or prognosis [23, 24]. The largest analysis in patients with myocardial infarction showed that age was the major factor for atypical presentation, and that an atypical presentation carried a high risk for serious outcomes and a much higher mortality than a typical presentation [25] – another disturbing fact questioning the frame-works of certain formal triage tools relying on “typical case presentation”.

In the last decade, several studies explored the predictive validity of all major triage tools [26–28]. Furthermore, the reliance of triage on the experience and intuition of the clinician has been pointed out [29]. Likewise, its tendency to place a major proportion of patients (up to 49%) into “intermediate acuity” has been noted [30–32]. These shortcomings led to various attempts to improve the overall performance of triage by modifying the system itself or by teaching interventions to increase adherence to the algorithm [33–35]. Other approaches focused on the use of new technology to create computer-based triage systems, with promising results [30, 36, 37]. Electronic triage systems use algorithms, which are able to take into account a much greater number of predictor variables to perform triage than traditional, established triage systems [38]. Furthermore, electronic triage systems can integrate additional outcome measures for risk stratification, such as mortality, admission to an intensive care unit, or the probability of elevated troponin or lactate levels as surrogate markers for acute coronary syndrome or hypoperfusion, respectively [36].

Another promising approach to the improvement of formal triage is driven by symptom-oriented research: The first studies on the prognostic value of different presenting complaints for short- and long-term outcomes were conducted in all-comer populations [39–41]. Unfortunately, these studies focused on single, main, presenting, or so-called “chief complaints”. Therefore, it was never taken into account that most patients present with more than one symptom [42, 43]. Constructs of “chief complaint” or “main symptom” heavily rely on several steps of selection and reduction of information. First, the selection of individual patients: of all symptoms, patients tend to choose and present the ones deemed to be most important to them. Only systematic interviewing may elicit all symptoms perceived at presentation. Second, the individual physician’s selection: of the list of presenting symptoms, physicians tend to choose and record the so-called “chief complaint”, with a tendency to focus on frequent and specific presenting symptoms, such as chest pain, and a tendency to ignore nonspecific complaints [40].

In summary, the main findings of last decade’s research on symptoms as predictors for outcome at triage were the following:

1. *Nonspecific complaints*, such as weakness, were shown to be of prognostic significance, both in terms of diagnostic uncertainty [44] and survival [42, 45]. Furthermore, older patients with atypical symptoms [46], homecare impossible [47], nonspecific complaints [48], unexplained symptoms [49], general disability [39], no cardinal symptom [40], (acute) frailty [50], or falls [51] represent a particularly vulnerable population, usually carrying a worse prognosis than all other emergency patients [52].
2. *Chest pain* could no longer be shown to be predictive of mortality, but only for subsequent interventions and intensive care [42]. Chest pain patients are among the first to be assessed by emergency physicians, although prevalence and mortality of myocardial infarction have continuously declined in ED patients with chest pain in the last 20 years [53]. Interestingly, a faster decline of age-adjusted mortality in women with myocardial infarction – surpassing survival in men – was shown for a Swiss population [53], but this could not be shown

in the US [54]. It is still unknown why gender-related differences in outcomes are present in some healthcare systems but not in others; however, it is known that women have a different spectrum of symptoms when presenting with myocardial infarction [55]. Owing to a low awareness about these differences, women traditionally suffered from delays in pre-hospital and hospital assessment with associated higher mortality [56]. Therefore, the prospective assessment of symptoms at triage is still very much needed. Unfortunately, most studies [57–59] relied on retrospective assessment of information from medical records, which is highly associated with information bias.

3. *Dyspnoea* was previously known to be of prognostic significance [60], but the measurement of respiratory parameters at triage has remained problematic [34] despite its immense prognostic importance [61, 62]; simple clinical evaluation is a challenge [63]. In older patients particularly, the perception of dyspnoea is impaired. Therefore, the objective measurement of, for example, respiratory rate is of utmost importance in order to avoid under-triage. New technology might help in this regard [64, 65].

   Combination of vital signs with warning scores, for example in combination with biomarkers, could help to identify low-risk patients [66]. Other – non-traditional – "vital signs" such as mental status [67–69], mobility [70, 71] [72] and frailty [73] have been advocated.

4. Research on patients presenting with *multiple symptoms* showed an increased demand for resources and hospitalisation, but no evidence of adverse outcomes such as acute morbidity [74] or mortality [43]. Interestingly, certain combinations of symptoms, such as weakness and fatigue [75], may predict adverse outcomes – a strong indication that systematically assessing symptoms at triage may add prognostic information.

Advances due to symptom-oriented research at work-up

Patients presenting to EDs are a vulnerable population, as they face an unclear short-term future regarding the seriousness of their condition and mortality. Formal triage allows separation different groups at presentation, with short-term mortality ranging from 0% to 25%, depending on acuity and diagnosis [76]. However, establishing a sound diagnosis takes time, leading to further anxiety on the patients' side, as well as insecurities on the caregivers' side. Unfortunately, a longer ED length-of-stay carries a worse prognosis [77, 78], even when physiological, demographic and co-morbidity factors are taken into account. Therefore, an early and accurate diagnosis is the second cornerstone of emergency medicine. How can a precise diagnosis be established within a few hours after presentation to the ED? This process is commonly called "work-up" and consists of a standardised and stepwise approach to the patients' problems. First, the main problem has to be identified. As pointed out, there may be a difference between the patients' perceived main problems and the "chief complaints" defined by the caregivers. The most advanced recent studies have focused on the *post-hoc* classification of chief complaints by means of recurrent neural networks [79]. However, this technology is more useful for syndromic surveillance of a population than for the establishment of an accurate diagnosis in an individual. In the future, such algorithms have the potential to support diagnosis of ED patients in a short time. At present, the patients' complaints are categorised, and recent publications [80] presented long lists of over 500 complaints, some specific for a certain group of diseases (e.g., chest pain), and others nonspecific owing to the wide range of underlying disease (e.g., weakness or fatigue). Common to all specific complaints is the standardised work-up, algorithm or protocol assigned to each complaint. Most major EDs have access to protocol-based care, such as www.medStandards.org. Protocol-based care has been shown to be safe and effective in, for example, sepsis [81] or circulatory arrest [82]. In the case of sepsis it was not shown to be superior to usual care. However, there is still a lack of research on the economical, standardised every-day work-up of headache, leg pain, back pain, abdominal pain, chest pain and dyspnoea – specific complaints on the top-10 list in most EDs [42]. Reviews of the few studies on pathway- or protocol-based care in these fields have so far found limited evidence of their impact on outcomes [83], but barriers and critical factors in implementation still need to be identified [84]. Algorithms, pathways, standards and protocols have been embraced by emergency medicine at a very early stage, and no ED would relinquish its own protocols. Although some protocols are very similar across countries and continents [85], others differ widely [86]. Interestingly, the sheer adherence to protocols is highly associated with outcomes, such as mortality, more so than the content of the individual protocols [87].

There are different types of protocols. Some are symptom-based, others are problem-based or diagnosis-based. Diagnosis-based protocols are widely used in emergency medicine, but only "downstream" of the initial assessment in which the symptoms must be assessed and weighted, and differential diagnoses carefully considered before triggering a diagnosis-based protocol. There is indirect evidence that symptom-triggered protocols may be beneficial: in the case of specific complaints, the accuracy of ED diagnoses is high, whereas in nonspecific complaints, the accuracy of ED diagnoses is low [88]. This may in part be explained by the fact that no protocols exist for nonspecific complaints, but also by the wide range of underlying disease in nonspecific presentation, which favours the probability of a mismatch [89]. Therefore, in a nonspecific presentation, other concepts were developed for risk stratification, such as the frameworks of "acute morbidity" [74] or "acuity" [45, 48]. Both can support risk stratification in a phase in which diagnoses are still unclear. However, early disposition is preferred to a longer stay or even "wait-and-see" in the busy ED, where lack of resources is a major problem. Improving resource allocation merits more attention [90].

Advances due to symptom-oriented research at disposition

Once triage, work-up and initial treatment are completed, a disposition decision has to be made. Disposition should be based on prognosis [91], as disposition decisions are of medical and economic importance – the latter being of in-

creasing significance owing to waning resources in acute care. Therefore, hospitalisation of low-risk patients should be minimised in order to assign the remaining resources to high-risk patients. The four typical disposition decisions are discharge (home), admission (to hospital), direct intervention (e.g., in the operating room) or transfer of the patient (e.g., to specialised geriatric care) [92].

Discharge is indicated for patients at low risk (of complications, further deterioration, or death). This excludes patients needing hospitalisation for "logistic reasons". Therefore, risk stratification at disposition is of vital importance, death shortly after discharge being dreaded by all physicians. Patients who were evaluated in an ED and suffer from early unanticipated death at home could well be victims of medical errors [93]. Ten years ago, little was known about the frequency of such events or about factors that might contribute to them. In one large retrospective study, four topics emerged when patterns of potential preventable medical error were sought: atypical presentation, decompensating chronic disease, interpretation of vital signs and mental issues (including substance abuse) [93]. Similarly, in a large study of insurance claims data, altered mental status, dyspnoea and malaise/fatigue were more common among early deaths after ED discharge [94]. As only a few symptoms, such as skin rash or dysphagia can be used for the exclusion of notable risk [42], formal triage has emerged as the main tool to predict early and safe discharge.

Hospital admission is usually indicated for patients at risk of complications, further deterioration or death. Avoiding hospitalisation, on the other hand, has many advantages: most importantly, patients will most likely prefer this. With an ever increasing number of presentations, crowding is a long known problem for urban EDs in Switzerland [95] and worldwide [96, 97]. Crowding is the result of a mismatch between ED capacity and the number of patients presenting in a given period of time [98]. It is known, that crowding is associated with increased ED length of stay (LOS), risk of readmission, increased diagnostic error and increased mortality. [99, 100] "Wait and see" is therefore not an option, and optimising disposition is one of the key factors for efficient throughput management. Specialised units are among the alternatives studied. "Fast track units" have shown benefits in disposition of low-acuity patients [101]. However, disposition of medium-acuity patients is a substantial challenge, as fast-tracking is not an option. An isolated concept of a "midtrack area" for uncomplicated medium-acuity patients showed decreased ED LOS [102]. Other concepts, such as streamlining front-end operations, potentially lead to an improvement of ED LOS [103, 104]. However, all these concepts depend on accurate triage and the evidence for the optimal ED front-end strategy is highly debated [105]. The fact that up to half of all medium-acuity patients are hospitalised makes the economic significance of disposition evident. There are attempts to predict the safety of disposition [106] by use of models including variables such as gender, arrival mode, age and (vital) signs. Such models showed the feasibility of disposition prediction as early as at presentation to the ED [13, 107]. As an example, certain symptoms strongly predict hospitalisation (weakness, fatigue, dyspnoea, fever, vomiting, loss of appetite and speech disorder) [42]. This shows that we not only need to study evidence-based disposition in the future, but also the prediction of disposition in order to improve flow-management, thereby reducing unnecessary cost.

Specialised geriatric care is usually indicated for frail older patients in need of comprehensive assessment. Not all older patients are equally susceptible to (minor) stressors, such as urinary tract infections. Whereas most patients only experience a minor decline in function, followed by a return to homeostasis, frail patients are more seriously affected and do not regain their baseline level of health and independence [108]. the prevalence of frailty increases with age [109] and frail patients have a significantly higher risk for adverse outcomes, such as falls, institutionalisation and mortality, than non-frail patients in the same age group [110–112]. Several tools for identification of frail patients have been introduced and studied [113]. An easy-to-use screening tool is the Clinical Frailty Scale (CFS) developed in the Canadian Study of Health and Aging (CSHA) [114]. The CFS has been found to be an independent predictor for in-hospital mortality and LOS in inpatients [115, 116]. Other simple measures for identifying frailty have been identified; gait speed, for example, has been shown to be the best parameter to rule out frailty in community-dwelling older people due to its high sensitivity [117]. However, outcomes in patients are not solely dependent on their degree of frailty (susceptibility), but also on the acute illness severity (stressor). The combination of the CFS as a screening tool for frailty with an aggregated vital sign score as a measure of acute illness severity leads to improved prediction of inpatient mortality [73]. In addition, disposition decisions frequently change after observation of frail older patients [100]. Future research should focus on the reduction of early and risky discharge in frail older patients while improving early identification of frailty and the necessity of comprehensive geriatric assessment. Hospitalisation of frail older patients is not free of risk, particularly in acute care settings. The use of physical restraints, use of a urinary catheter, occurrence of a fall, a pressure ulcer, sleep deprivation, acute malnutrition, dehydration and occurrence of aspiration pneumonia increased mortality in hospitalised delirious patients in a graded manner, and were responsible for a significant percentage of the association of delirium with death [118]. Therefore, only thorough consideration of possible harms versus benefits can predict the likelihood of successful hospitalisation, the question being: "Is this patient safe for admission?" [119]

Conclusion

The last decade's advances in symptom-oriented research in emergency medicine were the definition of nonspecific complaints as an entity, the shift from triage based on expert opinion to triage based on evidence, and risk stratification improving work-up, resource allocation and disposition. Future research and training should therefore focus on the constant guaging of risk and benefit, diagnosis and prognosis, as well as admission versus discharge.

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