Ultrasonography to Assess Suspected Bone Fractures: Beliefs and Usage in General Practice in Germany – A Cross-Sectional Survey

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Abstract

Background: Over the last two decades, ultrasonography (US) has been shown to be an accurate tool for the diagnosis of suspected bone fractures; however, the conditions for integrating this usage of US into general practice need to be specified. In this study, we surveyed German general practitioners (GPs) to assess their knowledge, attitudes, and utilization of US for the diagnosis of suspected fractures. Methods: Notification of the study, a self-designed questionnaire, and a reminder were sent by mail to 600 randomly selected GPs in Saxony and Saxony-Anhalt. Results: The response rate was 47.7% (n=286), and respondents did not differ from the population of all GPs in respect to sex and practice type. Of all GPs surveyed, 48.6% used an US device in their practice. On average, GPs diagnosed six patients with suspected fractures per month, yet only 39.3% knew about the possibility of ultrasonographic fracture diagnosis, and only 4.3% of GPs using US utilized it for this purpose. Among participants, 71.9% believed that US is inferior to conventional X-rays for the diagnosis of bony injuries. Users of US were better informed of and used this imaging modality more often for fracture diagnosis than non-users. Conclusion: The need to rule out possible fractures frequently arises in general practice, and US devices are broadly available. Further efforts are needed to improve the knowledge and attitudes of GPs regarding the accuracy of US for fracture diagnosis. Multicenter controlled trials could explore the usefulness and effectiveness of this seldom used diagnostic approach.

Background

The use of ultrasonography (US) is increasing and progressively extended to new indications in almost all disciplines of modern medicine for procedural, screening, and diagnostic purposes [1]. As a diagnostic instrument, point-of-care US is substantially integrated into health care in hospital and outpatient settings [2]. In addition to the diagnostic evaluation of inner organs, blood vessels, muscles, and soft tissues, it has been demonstrated that US has a high sensitivity and specificity for the diagnosis of suspected bone fractures. The detection of cortical discontinuities, step formation, and subperiosteal hematoma can be used as a diagnostic tool after acute trauma. In a systematic review Chartier et al. [3] reported
on 30 publications showing a high sensitivity (64.7-100%) and specificity (79.2-100%) compared to plain radiographs in patients with suspected fracture of the long bones. Two more systematic reviews [4, 5] focused on distal forearm fractures only and found an even higher accuracy. An overview for the diagnostic accuracy of ultrasonography used for different fracture locations and patient groups was published by Schmid et al. [6]. The accuracy was higher for fractures of the humerus, the forearm, the ankle, and the long bones in general, as well as fractures in children. It was lower for fractures of the short bones of the hands and feet, and in adults.

The main advantages of US compared to conventional radiography are no radiation exposure, lower costs [5], and wider availability in non-hospital settings. Moreover, evidence suggests US may have higher accuracy than conventional radiographs for certain injuries, such as rib fractures [9] and early scaphoid fractures [10].

The use of US among general practitioners (GPs) in Europe differs widely, from less than 1% in Austria, Catalonia, Denmark, and Sweden, up to 45% in Germany and 67% in Greenland [8]. Heidemann et al. [2] reported that ultrasound devices were available for about 70% of German GPs. They also mentioned a lower availability of US devices (32.1% of all GPs) for the area of former East Germany.

The vast majority of published studies dealing with US-guided fracture diagnosis refer to observations in emergency departments [6], while very few studies report on outpatient settings [11,12].

The aim of this study was the exploratory description of the utilization of US, knowledge and attitudes towards fracture diagnosis based on US, and referral behavior dealing with suspected fractures among German GPs. Furthermore, differences in the respective aspects between physicians using or not using US as diagnostic tool and between GPs with long or short driving distances to the next radiographic unit were investigated.

Methods

Sampling and design

We performed a cross-sectional survey among GPs from the federal states Saxony (n=2733 GPs) and Saxony-Anhalt (n=1445). Addresses were gained from publicly accessible registers, and the contacted
GPs were selected from the register using random numbers (n=400 Saxony, n=200 Saxony-Anhalt). A response rate of about 25 % was expected. The selected GPs first received notification of the study and then the questionnaire one week later, both via mail. A reminder was sent seven weeks after sending the questionnaire. Responses could be returned by fax or mail. We received further pooled sociodemographic data of all GPs in Saxony and Saxony-Anhalt from the Associations of Statutory Health Insurance Physicians (Kassenärztliche Vereinigung), including average age, sex, and registration for reimbursement of US-diagnostics.

**Questionnaire**

The questionnaire was self-designed with content-related input from two experienced GPs. In the process of development, a medical student, two GPs, and two social scientists were involved. We pre-tested the questionnaire to verify face validity by piloting the questionnaire with two groups of six GPs, followed by additional feedback discussions. After minor revisions, the questionnaire was considered feasible by piloting physicians and could be completed in five minutes. The diagnostic scores and tools mentioned in the final question of the questionnaire were compiled through an unsystematic literature search. A translated version of the questionnaire is available as supplement (Supplement 1).

**Statistical analyses**

Data was analyzed using SPSS 25 (IBM SPSS Inc., Chicago, USA). Sociodemographic characteristics of the sample were presented descriptively (means, standard deviation, relative and absolute frequencies). Users and non-users of ultrasonography were compared in bivariate cross tabulations regarding their knowledge and attitude towards US (relative and absolute frequencies). These differences were tested for statistical significance using chi-square tests (with Fisher-Exact correction as necessary). Further characteristics (e.g., suspected fractures after trauma, referring patients with suspected fractures) were analyzed in univariate statistics. The criterion of statistical significance has been set to an error probability of p<0.05. Because of the small sample size, the present inference statistics omit a correction for serial testing and are therefore exploratory.

**Ethics approval and consent to participate**
According to the Model Professional Code for Physicians [17], an explicit ethics approval was deemed unnecessary for this study because no personal data of patients was collected. The participating GPs were informed in written form about the use and publication of their anonymized data and consented to this explanation by sending back the filled out questionnaire voluntarily.

Results
Of the 600 mailed questionnaires, 306 questionnaires were returned (51.0%). Of these questionnaires, 286 were fully completed (47.7% response rate). Of the 286 completed questionnaires, 61 responses (21.3%) were received after a mailed follow-up reminder. A non-responder analysis showed no differences between responding GPs and non-responders with regard to sex, academic title, and specialization.

Sociodemographic data of the surveyed sample is given in Tab.1. The study sample and the total population of GPs in Saxony and Saxony-Anhalt did not differ significantly in respect to sex and type of practice.

Use of ultrasound
While only 38.5% of all GPs were registered for reimbursement of US diagnostics, among the surveyed GPs, 55.6% stated that there was a sonographic device available in their practices, and 48.6% used it. There were no differences in the availability of US devices between urban or rural areas (major cities: 55.8%; small towns: 54.7%; rural areas: 58.3%; p=0.876). The GPs using US reported performing on average 17 (mean=16.7, median=10, right-skewed distribution) examinations per week. The most frequently examined structures were the abdomen, the thyroid gland, and the kidneys (including the urinary passages). Only 4.3% of GPs using US stated that they used US regularly for the imaging of bone structures.

Knowledge and beliefs
The beliefs and attitudes regarding the use of US for suspected fractures among GPs are summarized in Fig. 1. The majority of respondents (71.9%) believed that US is inferior to conventional X-ray in diagnosing bone injuries. While 39.3% of GPs stated to have knowledge of this imaging modality, only 19.3% judged it as relevant for their own practice and 7.8% had any practical experience with
fracture diagnosis via US.

GPs using US imaging in their practice reported significantly more often to have considered the application of US for fracture diagnosis, to have used US for this purpose, and to think that fracture diagnosis via US imaging might be relevant for their own work.

**Diagnostic routines and referral behavior**

Suspected fractures after trauma appear to be a frequent occurrence for consultation in general practice. Respondents estimated six patients per month visit their practice with a suspected fracture (mean=6.4, SD=10.2; median=3; IQR=9). We asked GPs about criteria taken into consideration when deciding whether to refer patients with suspected fractures for further imaging procedures. GPs considered anamnesis, persisting afflictions, dysfunctions, and pain to be the most relevant criteria (96.8 - 99.0%). The presence of swellings, hematoma, and their gut instincts were used as decision criteria as well (87.0 - 93.0%). Only 33.3% of GPs rated the use of scores or other clinical decision tools as “rather relevant” or “relevant”.

The GPs were asked if and to which specialty they would refer patients with suspected fractures. The answers are summarized in Fig. 2. GPs from major cities were more likely to refer their patients to a radiologist than their colleagues from small towns or rural areas (major cities: 51.3%; small towns: 22.6%; rural areas: 26.2%; p<0.001), whereas there was no statistically significant difference concerning referrals made to a surgeon (major cities: 60.5%; small towns: 66.1%; rural areas: 65.5%; p=0.711) or to the nearest emergency department (major cities: 15.8%; small towns: 27.0%; rural areas: 21.4%; p=0.188). No significant differences in referral behavior between users and non-users of US were found.

When asked to consider their level of confidence during the diagnostic process, 9.1% of the GPs indicated feeling totally uncertain, 24.4% rather uncertain, 49.8% rather confident, and 16.7% completely confident. When asked about shared decision making with patients, 98.5% of the GPs indicated they discuss the likelihood of a bone fracture diagnosis with patients (73.1% “yes, always”, 25.4% “rather yes”), and 92.0% (57.6% “yes, always”, 34.5% “rather yes”) decided on further diagnostic procedures with patients or patients’ relatives.
Influence of distance to radiological unit

The majority of responding GPs considered their practice to be situated in small towns (n=117; 42.1%), while 30.2% (n=84) were situated in rural areas and 27.7% (n=77) in major cities. The times needed to reach the nearest surgery, radiology, or emergency department were recorded as estimated driving minutes by car. GPs working in rural areas estimated a median driving time of 15 minutes for all three locations (minimum 0, maximum 100 minutes, IQR 10 minutes). To reach a radiology department took 10 minutes in small towns and 6 minutes in major cities. The emergency department was reachable in 10 minutes and an outpatient surgery in 5 minutes in both small towns and major cities (all times are given as medians).

GPs who stated that US for the diagnosis of suspected fracture was rather relevant or relevant for their own practice were, on average, situated farther from their nearest surgeon (mean [SD]: 13.0 [±9.0] vs. 8.8 [±6.6] minutes; F=4.89, p=0.003), radiological (16.4 [±14.9] vs. 11.1 [±7.7] minutes; F=3.17, p=0.025) or emergency department (mean: 14.7 minutes [SD=9.9] vs. 10.9 [±8.5] minutes; F=6.13, p>0.001). A similar correlation was found for GPs who had considered using US for fracture diagnosis. There were no correlations between the distances to the next surgeon, radiology, or emergency department and the use of US or referral behavior.

Discussion

In this study, we surveyed a random sample of GPs in Germany (Saxony and Saxony-Anhalt) regarding their knowledge, attitudes, and utilization of US for the diagnosis of suspected bone fractures. Although half of the responding doctors used US as diagnostic imaging modality in their daily routine, its accuracy and potential for detecting bone injuries were grossly underestimated. Around one-third of those surveyed knew that US can be used in fracture diagnosis. Yet, more than two-thirds believed US was inferior to conventional radiographs, and less than eight percent had experience with ultrasonographic investigation of bone structures.

In a search of recent literature, we found no comparable studies dealing with US for fracture diagnosis in general practice. Jacobs et al. [7] investigated the effect of the introduction of teleradiology on the number of performed radiographic examinations for suspected fractures in a remote general practice.
The possibility of making a diagnosis by the GP reduced the number of unnecessary referrals to the hospital, and more patients with fractures were treated in the general practice rather than the hospital. A similar effect might be presumed for the use of US as an addition to the clinical examination of suspected bone fractures.

**Implications for future practice**

We found that GPs regularly encounter suspected bone fractures, and half of all GPs own an US device. A further evaluation of US for the diagnosis of suspected fractures in general practice seems promising and possible.

For safe and cost-effective patient care, an accurate imaging modality to rule out suspected fractures is needed. Today, conventional radiographs are most frequently utilized to make a diagnosis [3]. Radiographs are widely available in Germany, as illustrated by the result that 75% of the GPs from rural areas reported the closest radiology department to be reachable in less than 20 minutes driving by car.

Our findings show that 43% of GPs refer their patients to the radiology, even if a fracture seems to be unlikely. This finding suggests a demand for specific tools with a high negative predictive value to help rule out fractures with sufficient certainty. Consequently, the high number of radiographs performed to rule out unlikely fractures might be reduced.

There are clinical scores and suggestions for evidence-based diagnostic algorithms for certain fracture sites (e.g., Ottawa Foot and Ankle Rules [OFAR]) which help to enhance the pretest probability for radiographic imaging. These tools might help to reduce the radiation exposure for patients, especially for children and pregnant women who are particularly vulnerable. However, this survey revealed that GPs use such scores only rarely to support their suspected diagnosis. The potential of combining clinical scores and US was pointed out by Jonckheer et al. [13] and investigated by Canagasabey et al. [14] and Tollefson et al. [15], who combined the sensitive but unspecific OFAR with bedside sonography, thereby increasing the specificity of the testing. It would be helpful to formulate such clear diagnostic tools including US for general practice and other outpatient settings to reduce the number of radiographic examinations, thus avoiding unnecessary
costs and radiation exposure.

**Implications for future research**

Possible benefits of daily routines using sonography for the diagnosis of suspected fractures need to be carefully investigated. It remains to be seen whether fracture US in general practice can improve patients’ safety and comfort in addition to reducing costs. The diagnostic process for suspected fractures with US should therefore be assessed in prospective multicenter studies. Further studies of test performance in general practice or other outpatient settings with a relatively low pre-test probability for fractures should also take into account organizational and financial aspects, safety, and practicability.

Two-thirds of GPs believed US to be helpful for fracture diagnosis, indicating openness for this new application of the well-known diagnostic device. However, 71.9% of GP respondents had greater trust in conventional radiographs than in sonographic imaging to confirm suspected fractures. In addition, GPs indicated radiological departments were easily accessible, with a mean driving time of only 11 minutes from their general practice. This finding indicates the acceptance of GPs for US as diagnostic tool for suspected fractures may only be improved by providing clear evidence and convenient recommendations for daily practice.

**Strengths and limitations**

To our knowledge, this study is the first to investigate the attitudes and beliefs of GPs toward US for fracture diagnosis. For a mailed questionnaire, the response rate was substantial [16]. Additionally, there were no differences regarding sex and type of practice between the study population and all GPs from Saxony and Saxony-Anhalt, indicating representativeness of the sample.

However, there are a few limitations of this study. Our sample is not representative of all German GPs, as there are differences in the presence of US devices in general practices across the federal states [2]. Because of the cross-sectional design, we relied on estimates reported by GPs of the incidence of suspected fractures. In addition, a source of bias might be that physicians who are routinely using US in their practice may be overrepresented among the respondents (US device available for 55.6% of the responding GPs vs. 32.1% as reported by Heidemann et al. [2]). These
physicians may overestimate the potential and benefits of US for fracture diagnosis. However, given these findings of low utilization and poor knowledge of US for suspected fractures, it is reasonable to assume the need for information and clear evidence in this field is even higher for the total GP population in Germany.

Conclusion
To rule out suspected bone fractures is a frequently occurring task in general practice, and US devices are available for half of GPs. Further efforts are needed to improve the knowledge and attitudes of GPs regarding the accuracy of US for fracture diagnosis. Multicenter controlled trials could explore the safety, usefulness, and effectiveness of this yet seldom used diagnostic approach for suspected fractures.

List Of Abbreviations
GP – general practitioner
US – Ultrasonography

Declarations

Ethics approval and consent to participate
According to the Model Professional Code for Physicians [17], an explicit ethics approval was deemed unnecessary for this study because no personal data of patients was collected. After being informed of the study, all participants completed this anonymous survey on a voluntary basis.

Consent for publication
The participating GPs were informed in written form about the use and publication of their anonymized data and consented to this explanation by sending back the filled out questionnaire voluntarily.

Availability of data and materials
The anonymised datasets gained from the survey and analysed during the current study are available from the corresponding author on reasonable request.

Competing Interest
TF is an associate editor in the editorial board of BMC Family Practice. There are no further competing interests.
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**Author's contribution**

GLS and BK designed the questionnaire, conducted the survey, read out and interpreted the results, drafted and reworked the manuscript. MH revised the questionnaire, did the statistical analysis of the gained data, discussed the results critically and reworked the manuscript several times. TD designed and revised the questionnaire, helped with the statistical analysis of the data, discussed the results critically and reworked the manuscript several times. TF had the idea for the research question, designed and revised the questionnaire, discussed the results critically and reworked the manuscript several times. All authors read and approved the final manuscript.

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Table 1:

Description of the study population: sex, type of practices, and approval for reimbursement of ultrasound diagnostic.
|                           | Sample (n=286) | Total population (N=4178) |
|---------------------------|----------------|--------------------------|
| sex                       |                |                          |
| male                      | 118 / 286 (41.3%) | 1642 / 4178 (39%       |
| female                    | 168 / 286 (58.7%) | 2536 / 4178 (60%       |
| types of practices        |                |                          |
| single practice           | 202 / 286 (70.6%) | 3126 / 4169 (75%      |
| medical care center       | 23 / 286 (8.0%)  | 343 / 4169 (8%        |
| joint practice            | 61 / 286 (21.3%) | 700 / 4169 (16%      |
| approval of ultrasound    | n.a.           | 1609 / 4178 (38%      |
| users of ultrasound       | 139 / 286 (48.6%) |                      |
| ultrasound unit In practices | 159 / 286 (55.6%) |                      |

**Figures**
Knowledge, beliefs, and attitudes toward US for the diagnosis of bone injuries:

- I think that US for fracture diagnosis is inferior to conventional X-ray, N=267; p=0.828
- I think that US for fracture diagnosis can be helpful, N=277; p=0.209
- I think that US for fracture diagnosis can simplify medical care, N=277; p=0.753
- I think that US for fracture diagnosis makes medical care more efficient, N=279; p=0.310
- I am interested in the topic of US for fracture diagnosis, N=283; p=0.392
- I already heard about the application of US for fracture diagnosis, N=289; p=0.241
- I think the application of US for fracture diagnosis may be relevant for my practice, N=283; p=0.003
- I already thought about the application of US for fracture diagnosis, N=280; p=0.002
- I already used US for fracture diagnosis, N=283; p=0.001

Figure 1

Knowledge, beliefs, and attitudes toward US for the diagnosis of bone injuries of GPs who use US compared with GPs who do not. Data is given as percentage of all responses to the respective question (N). The p-values refer to the corresponding null-hypotheses that there are no differences between both groups.
The referral behavior of GPs for patients with suspected bone fractures is visualized for the cases that a fracture was (a) likely or (b) unlikely. Data is given as percentage of all given answers to the respective question.