Med Ultrason 2020, Vol. 22, no. 4, 445-450
DOI: 10.11152/mu-2530

Evaluation of optimal education level to implement structured reporting into ultrasound training

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Abstract

Aims: Reporting of head and neck ultrasound (HNU) has been outlined to be a major obstacle during ultrasound training due to a lack of standardized structure, content and terminology. Consequently, overall report quality differs significantly between various examiners posing a severe risk factor for information loss and miscommunication. Therefore, the present study's purpose is to compare the overall quality of free text reports (FTR) and structured reports (SR) of HNU at various stages of training in order to determine the optimal educational level to implement SR. **Material and methods:** Typical pathologies in HNU were reported upon using SR and FTR by medical students, junior residents and senior residents. The reports were assessed for overall quality, time efficiency and readability. Additionally, user satisfaction was determined using a questionnaire. **Results:** SRs exhibited a significantly superior report quality (93.1% vs. 45.6%, p<0.001) at all training levels. Overall time efficiency was significantly better for SRs, especially at the stages of medical school and early residency (89.4 s vs. 160.2 s., p<0.001). Using structured reporting also increased user satisfaction significantly (VAS 8.6 vs. 3.9, p<0.001). **Conclusions:** Implementing structured reporting of HNU results in a superior report quality at all training stages. Greatest benefits for time efficiency are achieved by implementation during medical school. Therefore, structured reporting of HNU should be implemented early on in the training of HNU.

Keywords: medical education level; ultrasound training; structured reporting; free text reporting; training effect

Introduction

Head and neck ultrasound (HNU) is the accepted diagnostic modality of choice for a multitude of conditions in otorhinolaryngology [1-6]. Contributing factors are the high availability, the safe applicability for all patients and in particular the autonomous use by the treating head and neck surgeon [7-9]. While performing ultrasound is taught widely throughout medical school and residency, these efforts are usually not well structured and dependent upon the academic teacher or consultant in charge. Additionally, the supervised aspect of training usually ends with the examination, leaving the process of reporting itself rather unattended. While this fact may be understandable due to the limited amount of time for supervised work and teaching during clinical practice, it conflicts with the importance of reporting. As a consequence, the report quality may not hold up to the ex-

Received 02.04.2020 Accepted 31.05.2020
Med Ultrason
2020, Vol. 22, No 4, 445-450
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amination quality, causing inter-professional misunderstandings and information loss, potentially downgrading treatment quality [10-13].

The implementation of structured reports (SR) into clinical practice has been shown to overcome these obstacles by standardizing the report content and terminology of HNU and other imaging techniques [14-25]. On the one hand, the use of SRs decreases the risk of missing key structures and increases the user satisfaction of examining and referring physicians [21,22,26-30]. Moreover, the implementation of SRs into clinical training may enhance the learning curve by pointing out relevant anatomical structures, automatically determining clinical classifications and offering correct phrasings [20,24,31]. Taken together, these factors may contribute to higher report quality and comprehensiveness during the modality's training process [4,15,24]. Additionally, structured reporting may be grounds for improved research and education [32]. Aspects of SR may be linked to the DICOM-data of certain pathologies which can be analysed for scientific purposes or used for the training of medical students and residents.

While different clinical studies were able to demonstrate that the implementation of structured reporting of HNU increases report quality and time efficiency [19,20,23], there is no data at which the level of training SRs should be introduced in order to accomplish the best possible benefit. Even though it may be suggestive that the highest profit can be achieved by the earliest possible implementation, the opposite could be the case. The use of free text reporting (FTR) inevitably leads to the acquisition of an extensive knowledge of the diagnostic modality and its reporting through repetitive free text formulation and the necessary terminology and structure in order to do so [23]. Secondary, a steeper learning curve in structured reporting may arise from previously acquired knowledge.

Therefore, the present study's objective was to evaluate the optimal education level to implement structured reporting into ultrasound training by the differential analysis of its training effects during medical school, junior residency and senior residency.

In accordance with the literature, we hypothesized that training effects are marked by acquiring new expertise and skills that consequently affect attitudes, decisions and actions [20,33]. Therefore, improvements in report quality and time efficiency were regarded as indicators of the training process. In addition, we assessed the user satisfaction using SR and FTR.

Material and methods

We compared the benefits of SR over FTR during various stages of training. In detail, differential report analysis of 58 corresponding reports by medical students, 24 by residents with limited experience in HNU (junior residents) and 43 by residents with extensive experience in HNU (senior residents) were included in the study (n=250) (table I).

As previously described in the literature, the number of reports needed was computed based upon the expected effect size when comparing high quality reports generated by FTR and SR [34]. We hypothesized that 40% of FTR and 80% of SR would meet this criterion. The power was set to 80% with a significance level of α=0.05. Using these parameters, the minimum number of reports required within each collective was calculated to be n=44 (22 reports in each group) [35].

Free text reporting was carried out using a standardized, handwritten template which used to be our department's standard. Structured reporting was performed through a specifically designed online-based software (Smart Reporting GmbH, Munich, Germany, http://www.smart-reporting.com) for HNU as previously published [19,20,23].

Time required to complete the report was documented during reporting. All 250 anonymized reports (125 FTR and SR each) were evaluated for overall report qual-

Table I. Details about participating medical students and residents

Characteristics	Medical students	Junior residents	Senior residents
Number of participants	58	24	43
Years of training (e.g. medical school or residency)	2.71 ± 0.81 years (range: 1-4 years)	2.0 ± 0.94 years (range: 1-4 years)	4.11 ± 1.91 years (range: 1-6 years)
Gender	Female: 55.2%	Female: 50%	Female: 33.3%,
Self-evaluation concerning ultrasound experience	Insufficient: 0% Poor: 17.2% Moderate: 58.6% High: 24.2% Very High: 0%	Insufficient: 0% Poor: 0% Moderate: 70.1% High: 25.0% Very High: 4.9%	Insufficient: 0% Poor: 0% Moderate: 33.3% High: 33.3% Very High: 33.3%

ity and readability by two independent board-certified otorhinolaryngologists accredited by the German Society for Medical Ultrasound (DEGUM). Overall report quality was defined as the compound of report completeness, pathological detail, terminology and readability. Consequently, report quality was categorized as very high (80 - 100%), high (60 - 80%), moderate (40 - 60%), poor (20 - 40%) or insufficient (0 - 20%). Besides, user contentment was evaluated using an established questionnaire [19,20,23]. Participating medical students and residents were surveyed about practicability (question 1), usefulness in everyday practice (question 2), improvement in report-quality (question 3), time efficiency, timewise economy (question 4), justification of additional time needed (question 5), benefits for inexperienced physicians learning ultrasound examinations (question 6) and reporting (question 7) of the head and neck, usability by intuition (question 8) and clarity of arrangement of the template (question 9) using a ten-point visual analogue scale.

Statistical analysis

Data are reported as the mean ± standard deviation (SD). Wilcoxon signed-rank test for paired nominal data was used to compare overall completeness, level of detail and time required. Mann-Whitney U test was used to compare questionnaire results because of the nonparametric-distribution. Linear regression analysis was applied to determine correlations. A p-value of less than 0.05 was considered statistically significant. Cohen's kappa was used to evaluate inter-rater reliability. All statistical analyses were performed using SigmaPlot 12 (Systat Software, Inc., San Jose, CA, USA).

Results

Overall, 250 reports (n=125 for SR and FTR each) were included in this study. All reports were assessed by two board-certified otorhinolaryngologists accredited by the German Society for Medical Ultrasound (DEGUM) resulting in a total of n=500 ratings (n=250 ratings per reviewer).

Analysis of included reports disclosed that the use of SRs leads to an increased overall report quality in all investigated phases of training (92.7% vs. 43.1%, $p<0.001$). To be precise, structured reporting achieved higher report quality ratings during medical school education (89.2% vs. 53.0%, $p<0.001$), junior residency (91.8% vs. 35.1%, $p<0.001$) as well as senior residency (94.8% vs. 50.3%, $p<0.001$, fig 1).

As part of report quality, readability, assessed using a five-point scale, was also significantly increased (100% vs. 50.4%, $p<0.001$, fig 2).

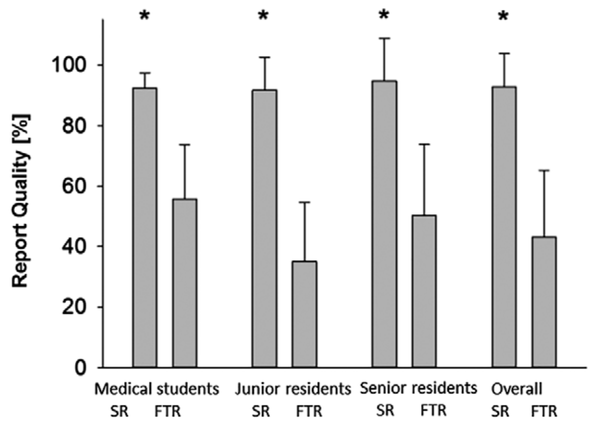

Fig 1. Results of report quality analysis. Structured reports (SR) achieve significantly higher ratings in terms of report quality during medical school, early and senior residency. Consequently, overall report quality including all training stages is significantly increased by SR. * $p<0.05$

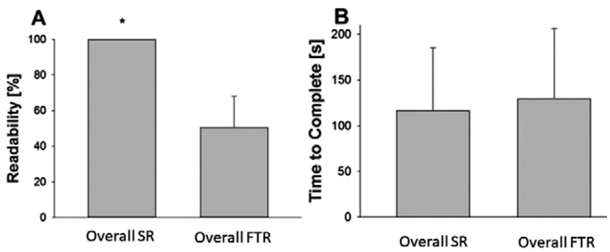

Fig 2. Results of overall readability and time efficiency analysis. Use of Structured reports (SR) results in a significantly better readability and a tendency towards an improved time efficiency throughout all training stages. * $p<0.05$

Time efficiency was defined as the difference in time needed to report between structured and free text reporting. Longitudinal analysis of the presented data revealed that implementation of structured reporting as early as possible is correlated with the highest benefits in terms of time efficiency without compromising report quality ($R=0.67$, $R^2=0.449$, $p<0.001$, fig 3).

In the following, overall report quality was classified and correlated as described above. This showed that poor to moderate report quality correlated with FTR (68.6% vs. 1.3%, $p<0.001$) whereas high to very high report quality correlated with SR (98.7% vs 31.4%, $p<0.001$). Moreover, linear regression analysis showed no significant correlation between overall report quality and time to complete the report ($R=0.0389$, $R^2=0.00151$, $p=0.63$). Inter-rater reliability was very high with a Cohen's kappa of 0.92.

The analysis of the user satisfaction questionnaire unveiled a significant preference for structured reporting throughout all training levels (8.4 vs. 4.8, $p<0.001$). Use

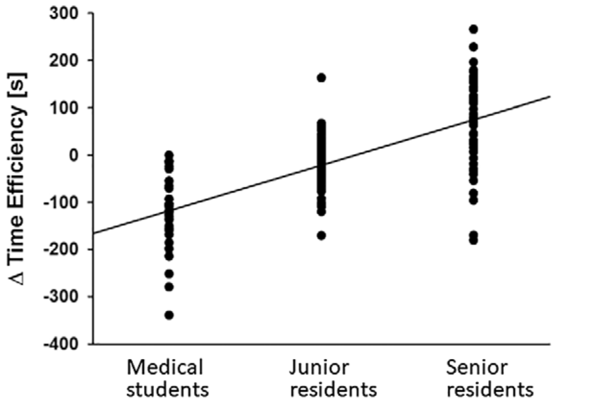

Fig 3. Longitudinal analysis of time efficiency throughout all training phases. Time efficiency was defined as the difference in time needed between structured and free text reporting. Longitudinal analysis reveals that the highest benefits in terms of time efficiency can be obtained through an implementation early on during training ($R=0.67$, $R^2=0.449$, $p<0.001$).

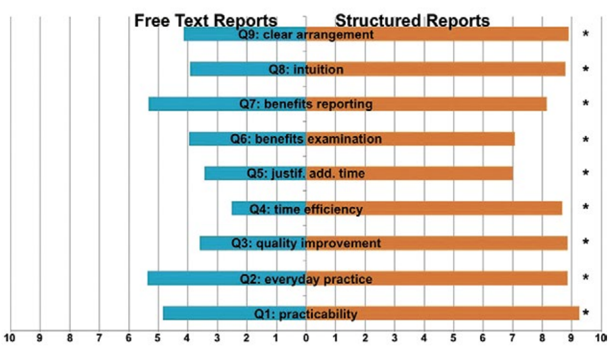

Fig 4. Visual analog scale (VAS) of questionnaire findings. User satisfaction throughout all training phases was evaluated with a questionnaire using a visual analog scale (VAS, 10: Complete agreement, 0: Complete disagreement). The questionnaire revealed a significant preference for structured reports in all categories. * $p<0.05$

of SR was regarded as applicable for everyday use (9.0 vs. 5.3, $p<0.001$), as time-efficient (8.8 vs. 4.0, $p<0.001$) and intuitive (8.7 vs. 5.3, $p<0.001$). Moreover, SR was regarded as supportive in both conducting the examination (7.5 vs. 4.8, $p<0.001$) and creating the report (8.4 vs. 5.7, $p<0.001$). Consequently, SR was thought to generate a higher level of report quality (8.8 vs. 4.0, $p<0.001$). A detailed analysis of questionnaires is shown in figure 4.

Discussions

The aim of the present study was to determine the optimal education level to implement structured reporting into ultrasound training by differential analysis of its teaching effects during medical school, junior residency and senior residency.

Our data revealed that using SR leads to a significantly improved overall report quality in all training levels (e.g. medical school, junior residency, senior residency). Mean time to complete the report was significantly reduced by using SR during medical school and junior residency. While time efficiency was better for the cohort including senior residents, user satisfaction analysis pointed out, that the additional time needed in this subgroup was likely to be well spent. Overall analysis of user satisfaction showed a clear superiority of structured reporting. These results are consistent with previous publications that were able to correlate the use of structured reporting with superior report quality for a wide range of diagnostic modalities [24,26-29,31,32,34,36].

The great acceptance and preference for SR by all cohorts potentially relate to the template's standardized appearance, the redundant reporting process which streamlines learning and the provided medical guidelines. A controversial topic of discussion in the early days of structured reporting was whether SR templates do offer the required degrees of flexibility for everyday clinical practice. Previous studies were able to deflect these concerns and point out that rigid reporting conditions are beneficial during the learning process [19,20,23,24,37,38]. It remained uncertain at which training level structured reporting should be implemented. This question is clearly answered by the presented data: Structured reporting resulted in reports with a significantly superior report quality already at the early stages of medical school. This effect was sustained all the way up to senior residency which is even more remarkable because the senior residency cohort consisted of physicians with a longstanding expertise in free text reporting. Consequently, an early implementation of SRs into HNU training seems to be more important than the fundamental knowledge of report structure, content and terminology acquired during years of FTR-based reporting. Additionally, an implementation as early as possible is correlated with the greatest improvement of time efficiency. This is also underlined by the fact, that other studies were able to demonstrate a sustainable longitudinal additive training effect of structured reporting with respect to time efficiency during residency [23]. When comparing time efficiency of structured and free text reporting one has to keep in mind that the cohort of senior residents were trained using FTRs for years. Therefore, the decrease of time efficiency using SRs in this cohort has to be carefully put in perspective. By implication, the early implementation of structured reporting to rather untrained medical students or junior residents is beneficial due to the immediate increase in report quality and time efficiency as well as due to an additive longitudinal training effect [20,23].

In parallel, participating medical students, junior and senior residents significantly associated the use of structured reporting with increased report quality. Additionally, structured reporting is perceived as a sustainable assistance in the longitudinal learning process. It remains uncertain if an increased report quality or a digitally assisted learning process leads to an improved treatment quality or outcome. These hypotheses have to be evaluated by future prospective clinical studies. It is however certain that the use of SRs improves adherence to clinical guidelines and consequently to evidence-based medicine [28].

Previous studies have pointed out a lack of curricular ultrasound training during medical school [10,20]. Additionally, implemented curricular ultrasound training is regularly comprised of teaching the most basic examination techniques while neglecting to cover pathological interpretation and reporting. Consequently, young residents often struggle to describe and interpret ultrasound findings which results in inadequate report quality [10,24,38]. This conflicts greatly with the crucial role of reporting. Any report of medical diagnostic procedures depicts the essence of the examination as it transmits its content and conclusion from the examining to the referring physician while raw examination data (e.g. images, videos, etc.) may not be available for review at all times. Therefore, diagnosis or correct classification as well as therapy may be impaired by insufficient reports [31]. A lack of training concepts during medical school has direct influence on the training of residents as ultrasound training has to be continued on an appropriate level. This makes residency training even more personnel- and time consuming and further increases the problem of staff shortage in most departments. SR may be of help in this scenario as it outlines relevant structures and topography to be reported on and terminology to describe these appropriately [37].

As a consequence, multiple studies have concluded that SR may facilitate the training process, reduce the incidence of missed pathologies and improve diagnostic and report quality [19,20,22,23,39]. At last, SR is known to significantly increase inter-rater reliability thus improving the comparability of reports especially in the context of treatment monitoring and big data analysis [15,27,40-42].

In **conclusion**, SRs produce reports with a significantly increased quality at a positive time efficiency. The greatest increase in both report quality and time efficiency can be observed in the cohort of medical students. Additionally, structured reporting leads to a longitudinal increase in time efficiency while upholding report quality. Consequently, we recommend implementation of structured reporting into training concepts of HNU as early as possible.

Acknowledgements: The authors thank all attending medical students and residents for their participation.

Conflict of interest: Wieland H. Sommer is the founder of the company Smart Reporting GmbH, which hosts an online platform for structured reporting. Matthias F. Froelich is an employee of Smart Reporting GmbH. The other authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article. This manuscript is part of medical doctoral theses presented by Mohamed Hodeib and Fabian Katzer at the University Mainz Medical School.

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