Routine Use of Structured Reporting in Whole-body Trauma CT Facilitates Quality Improvement

Beitrag der strukturierten Befundung der Polytrauma-CT zur Qualitätsverbesserung in der Routine

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ABSTRACT

Purpose Structured reporting (SR) is increasingly used. So far, there is minimal experience with SR in whole-body computed tomography (WBCT). The aim of this study was to investigate the value of routine use of SR in WBCT in trauma with a focus on reporting time, reporting errors, and referrer satisfaction.

Materials and Methods Reporting time and reporting errors of CT reports were prospectively quantified for residents and board-certified radiologists 3 months before and for 6 months after implementation of a structured report in the clinical routine. Referrer satisfaction was prospectively quantified by means of a survey before and after the implementation period of SR using a 5-point Likert scale. Before and after results were compared to determine the effect of structured reporting on WBCT in trauma at our institution.

Results The mean reporting time was lower when using SR (65 ± 52 min. vs. 87 ± 124 min., p = .25). After 4 months, the median reporting time was significantly lower with SR (p = .02). Consequently, the rate of reports that were finished within one hour rose from 55.1 % to 68.3 %. Likewise, reporting errors decreased (12.6 % vs. 8.4 %, p = .48). Residents and board-certified radiologists reported fewer errors when using SR with 16.4 % vs. 12.6 % and 8.8 % vs. 2.7 %, respectively. General referrer satisfaction improved (1.7 ± 0.8 vs. 1.5 ± 1.1, p = .58). Referrers graded improvements for standardization of reports (2.2 ± 1.1 vs. 1.3 ± 1.1, p = .03), consistency of report structure (2.1 ± 1.1 vs. 1.4 ± 1.1, p = .09), and retrievability of relevant pathologies (2.1 ± 1.2 vs. 1.6 ± 1.1, p = .32).

Conclusion SR has the potential to facilitate process improvement for WBCT in trauma in the daily routine with a reduction of reporting time and reporting mistakes while increasing referrer satisfaction.

Key Points:

1. SR for WBCT in trauma is feasable in clinical routine.
2. Reporting time in WBCT in trauma decreases by SR.
3. SR for WBCT in trauma has the potential to decrease reporting mistakes.
4. SR for WBCT in trauma might increase referrer satisfaction.

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ZUSAMMENFASSUNG

Ziel Die strukturierte Befundung (SR) findet immer breitere Anwendung in der radiologischen Befundung. Bislang gibt es jedoch kaum Erfahrung in der SR der Computertomografie (CT) beim Polytrauma. Studienziel war die Untersuchung des Beitrages der SR zur Polytrauma-CT hinsichtlich Befundungsdauer, Befundungsfehlern und Zuweiserzufriedenheit.

Material und Methoden Die Befundungsdauer und Befundungsfehler der CT-Primärbefunde wurden prospektiv für Weiterbildungsassistenten und Fachärzte 3 Monate vor (ohne SR) sowie in den ersten 6 Monaten nach Einführung der strukturierten Befundung in der klinischen Routine erfasst. Die Zuweiserzufriedenheit wurde mithilfe einer Befragung vor und nach der Einführung mittels 5-stufiger Likert-Skala erfasst. Die Vorher- und Nachher-Ergebnisse wurden verglichen, um den Effekt der SR bei der Polytrauma-CT an einem universitären Haus zu objektivieren.

Ergebnisse Die mittlere Befundungsdauer war mit der SR kürzer (65 ± 52 min vs. 87 ± 124 min, p = 0,25). Nach 4 Monaten war die mediane Befundungszeit mit der SR signifikant geringer (p = 0,02). In der Folge stieg die Rate an Befundberichten, die innerhalb einer Stunde finalisiert wurden von 55,1 % auf 68,3 %. Gleichzeitig sanken die Befundungsfehler (12,6 % vs. 8,4 %, p = 0,48). Sowohl Weiterbildungsassistenten als auch Fachärzte hatten mit SR weniger Befundungsfehler mit 16,4 % vs. 12,6 % beziehungsweise 8,8 % vs. 2,7 %. Die allgemeine Zuweiserzufriedenheit wurde verbessert (1.7 ± 0.8 vs. 1.5 ± 1.1, p = 0,58). Im Detail bewerteten die Zuweiser deutliche Verbesserungen bei Befundstandardisierung (2.2 ± 1.1 vs. 1.3 ± 1.1, p = 0,03), Konsistenz der Befundstruktur (2.1 ± 1.1 vs. 1.4 ± 1.1, p = 0,09) und Auffindbarkeit relevanter Pathologien (2.1 ± 1.2 vs. 1.6 ± 1.1, p = 0,32).

Schlussfolgerung Die SR hat das Potenzial, eine Prozessverbesserung bei der Polytrauma-CT in der täglichen Routine mit Reduktion der Befundungsdauer und Befundungsfehler bei Verbesserung der Zuweiserzufriedenheit zu ermöglichen.

Kernaussagen:
1. SR für die Polytrauma-CT ist in der klinischen Routine möglich.
2. Die Befundungsdauer für die Polytrauma-CT sinkt durch SR.
3. SR für die Polytrauma-CT hat das Potential Befundungsfehler zu senken.
4. SR für die Polytrauma-CT könnte die Zuweisezufriedenheit steigern.

Introduction

Trauma is a global public health problem accounting for 9 % of deaths worldwide and it is one of the leading causes of death among young people [1]. Mortality rates of severe trauma are reported between 4.6 % and 10.1 % [2–4]. Radiological imaging plays a pivotal role in the diagnostics of traumatized patients as a relative reduction of mortality of 13 % was shown when computed tomography (CT) is performed immediately after trauma [5]. Moreover, guidelines stipulate highly standardized workflows aiming to further reduce patient mortality [6–9]. Especially in whole-body CT for trauma, 2.4–12.9 % of injuries are missed [10–12]. Particularly those missed injuries might endanger a good clinical outcome of trauma patients. Accordingly, missed or delayed diagnosis aggregated to 11 % of deaths in a large-scale review of trauma deaths by Gruen et al. [13]. Hence, a high diagnostic accuracy of whole-body trauma is essential for further patient treatment and directly impacts patient outcome. Particularly in light of patient outcome, some efforts have been made to establish a useful way to report CT examinations of trauma patients, albeit only a few studies regarding whole-body trauma CT and the structure of the reports. In recent years, structured reporting (SR) has been promoted as a powerful tool to enhance the quality of radiology reports as it supports therapeutic decisions [14–16], including surgical planning [17–19], and it improves the communication and recall of reports [20–22]. At the same time, a reduction of dictation time is reported [23], reporting errors decrease [24], and referrers' satisfaction improves [21] in comparison to free-text reports (FTR). Only some studies have evaluated SR in the setting of emergency imaging, especially whole-body trauma CT, with heterogeneous results. To date, the value of SR in whole-body trauma CT is still unclear.

SR was recently implemented as a standard procedure for whole-body trauma CT at our hospital. Thus, the present study aimed to investigate the influence of structured reporting on reporting time and reporting mistakes and to measure the benefit of SR in the secondary assessment of whole-body trauma CT for referrers by using a referrers' survey.

Materials and Methods

This prospective study conforms to the Declaration of Helsinki and was approved by the local ethics committee (BO-EK-27012022). Written informed consent was waived because of the retrospective nature of the study and the risk of selection bias, with a lack of more severely injured patients who are physically or mentally unable to give consent.

Patients

Between 9/2020 and 6/2021 every patient older than 18 years who underwent a whole-body trauma CT examination at our insti-

▶ **Table 1** Standard whole-body imaging protocol and reformations. *Protocol can be extended to the lower extremities in the case of clinical signs of injury. Abbreviations: cCT – cerebral CT; CTA – CT angiography.

▶ **Tab. 1** Standardprotokoll beim Polytrauma und Reformationen. *Das Protokoll kann beim klinischen Verdacht auf eine Verletzung der unteren Extremität auf diese ausgedehnt werden. Abkürzungen: cCT – zerebrale CT; CTA – CT Angiografie.

Examination region	Acquisition	Slice thickness and plane of reconstructions (Kernel)
Head	Native angulated cCT	6.0 mm axial (Hr 40), 1.5 mm axial (Hr 40), 1.5 mm axial (Hr 68)
Aortic valve – vertex	CTA	0.75 and 1.5 mm axial (Hr 38), 1.0 mm sinuses axial and coronal (Hr 56), 2.0 mm cervical spine coronal and sagittal (Hr 56), 2.0 mm parasagittal to aortic arch (Hr 38)
Thorax – pelvic floor*	Spiral CT	3.0 mm axial (Br 38), 1.0 mm axial (Br 59), 1.0 mm axial (Bf 37), 3.0 mm coronal (Br 59), 3.00 mm sagittal (Bf 37), 3.0 mm thorax axial (Br 59), 3.0 mm thorax coronal (Br 59)

tution was included in the study. Age, gender, and injury severity score (ISS) were recorded for each patient.

CT protocol

For all patients, whole-body CT was indicated independently of the study by the trauma team and according to the current S3 guidelines [8]. All trauma scans are routinely performed with a 2 × 128-slice spiral CT scanner (Somatom Definition Edge, Siemens Healthineers, Erlangen, Germany), located directly next to the resuscitation area. All patients are positioned supine, with their arms on the body. Imaging and reformations follow a standardized trauma protocol (▶ **Table 1**), which can be expanded for additional clinical questions. Immediately after presentation of the initial images to the trauma team, reading of the complete data set is performed on a workstation with two high-resolution monitors at the emergency department (Coronis Fusion 6MP LED (MDCC-6430), Barco, Belgium) using the local picture archiving and communication system (PACS) (IMPAX EE R20 XIX SU1; Dedalus HealthCare GmbH, Bonn, Germany).

Reporting measures

Radiologists at our institution were not obliged to use the reporting software (Smart Radiology, Smart Reporting GmbH, Munich. https://app.smart-radiology.com) so it was still possible to use FTR. On this account, all reports not created with the reporting software (before and after the implementation of SR) were defined as FTR and all reports that were created with the reporting software were defined as SR. The template contains a standardized text about the procedure. Its descriptive part consists of 1500 elements. All sublevels in the findings section are a mixture of point-and-click, drop-down menus, pick lists, and free-text to describe certain pathologies more closely, e. g. to specify reconstruction planes and image numbers. Only pathological findings are automatically transferred to the impression section to facilitate a quick overview about all relevant injuries. The whole structure is given in **Supplement 1**.

Reporting time

Reporting time is logged in the radiology information system (RIS) for certain actions. For this study, the time point when the radiological technologist finished and sent the imaging study to the PACS and the finalization of the final report by the board-certified radiologist or the finalization of the preliminary report by the resident was documented in minutes.

Reporting mistakes

Experienced residents with requisite qualification give a preliminary report, which is reviewed and then signed by a board-certified radiologist as soon as possible. Board-certified radiologists write the final reports. The final report approved by a board-certified radiologist was defined as the standard of reference. To assess reporting mistakes, written final reports were checked for addendums and correction reports in the RIS for board-certified radiologists. For residents, the preliminary report and the final report were compared. Reporting mistakes were documented separately for residents and board-certified radiologists. The categories of reporting mistakes were established as described by Geyer et al. as (I) no missed injury, (II) missed injury with no clinical relevance, and (III) missed injury with clinical relevance [11]. Clinical relevance was given when further specific treatment of a lesion was required or if a lesion indicated a severe injury.

Referrer survey

An online referrer survey was carried out before the implementation of SR and after the 6-month implementation period. 363 medical doctors who are involved in trauma care received an email invitation for the survey consisting of 11 questions. The very first question of the survey filtered participants who regularly take part in the treatment of trauma patients. It was followed by 10 questions about details of the whole-body trauma CT reports. The respondents were given a 5-point Likert scale to indicate their consent to the given statements with 1 being "I strongly agree" and 5 meaning "I strongly disagree". Additionally, a 3-point Likert scale was used to indicate the importance of each statement with 1 meaning "This statement is important", 2 meaning "undecided", and 3 meaning "This statement is not important".

Statistical analysis

Statistical analyses were performed with RStudio 2021.09.0 (http://www.rstudio.com/). For statistic evaluation of the survey,

▶ **Table 2** Comparison of reporting times with and without SR for all, board-certified radiologists and residents. SD = standard deviation; SR = structured report; FTR = free-text report. p = p-value (*$p < .05$ statistically significant).

▶ **Tab. 2** Vergleich der Befundungsdauer mit und ohne SR für alle, Fachärzte und Weiterbildungsassistenten. SD = Standardabweichung; SR = strukturierter Befund; FTR = freie Befundung. p = p-Wert (*p < 0,05 statistisch signifikant).

	All		Board-certified radiologists		Residents	
	SR	**FTR**	**SR**	**FTR**	**SR**	**FTR**
n	178	230	75	114	103	116
Minimum (min)	4	5	6	5	4	6
Mean±SD (min)	65 ± 52	87 ± 124	68 ± 51	120 ± 262	62 ± 52	74 ± 57
25th percentile (min)	29	32	29	26	30	36
Median (min)	48	58	59	60	47	57
75th percentile (min)	91	102	100	108	85	94
Maximum (h)	5.2	19.0	4.0	19.0	5.2	5.2
p	.25		.28		.31	

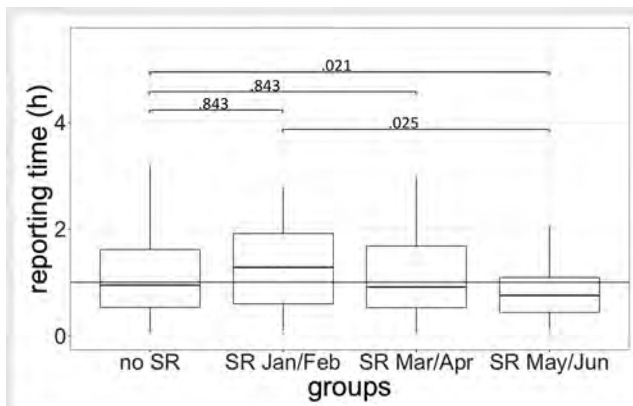
the Mann-Whitney U test was applied. The occurrence of reporting errors and reading times were compared by the Kruskal-Wallis-Test. The significance level was set at $p < .05$.

Results

A total of 408 patients with a mean age of 56.5 ± 20.3 years were included in this prospective single-center study. Of these, 275 (67.4 %) patients were male and 133 (32.6 %) were female. Their mean injury severity score (ISS) was 13.2 (range: 0–75). Before the implementation of SR, 187 reports were made and during the implementation period 178 SR reports were created. Additionally, 43 FTRs were finalized during the implementation period. Overall, 267 (65 %) CT examinations were performed during on-call duty at night or on weekends and 141 (35 %) were performed in the daytime during work hours. 189 reports were made by board-certified radiologists and 219 were primarily seen by radiology residents.

Reporting time

Throughout the whole study period, the median reporting time without SR took 58 minutes, whereas the median reporting time using SR was 48 minutes (▶ **Table 2**). Overall, the difference was not statistically significant ($p = .25$). Residents created their reports faster when using SR (median time: 47 minutes vs. 57 minutes; $p = .31$) and board-certified radiologists needed a median reporting time of 1 hour, regardless of the reporting mode ($p = .28$). For residents, the difference in reporting time was seen during both on-call duty and normal work hours (**Supplement 2**). The board-certified radiologists, however, showed a higher median reporting time during on-call duties when using the template (61 min. vs. 50 min., $p = .73$) and almost constant times during normal work hours (57 min. vs. 61 min., $p = .68$).



▶ **Fig. 1** Boxplots for reporting time before (no SR) and during the implementation of SR. The horizontal line indicates the one-hour reading time allowed by the ESER guideline. P-values are displayed above the boxplots.

▶ **Abb. 1** Boxplots für die Befundungsdauer vor (no SR) und während der Einführung der SR. Die horizontale Linie markiert eine Stunde Befundungszeit, die durch die ESER-Leitlinie vorgegeben ist. Die p-Werte sind oberhalb der Boxplots angegeben.

Before implementation of SR, 55.1 % of whole-body trauma reports were finished within one hour. Closer analysis of the implementation period revealed a longer interpretation time in the first two months with the reporting template than FTR. In the following months, that time decreased, and the proportion of reports lasting one hour or less rose to 68.3 %. After 4 months, there was a significant decrease of the median reporting time when using SR compared to FTR (45 min. vs. 58 min., $p = .02$) (▶ **Fig. 1**).

▶ **Table 3** List of all missed injuries or misinterpretations. Misinterpretations are italicized.

▶ **Tab. 3** Liste aller übersehener Verletzungen und Fehlinterpretationen. Fehlinterpretationen sind kursiv hervorgehoben.

Clinical relevance	No clinical relevance
1. Sternal fracture, high-grade stenosis of internal carotid artery, hematoma	1. Small liver contusion
2. Ligamental injury cervicothoracic junction	*2. Pulmonary compaction*
3. Razor blades in stomach	3. Type-A ankle fracture
4. Tumor and pulmonary embolism	4. Type-A ankle fracture
5. Liver contusion	5. Avulsion fracture Proc. coronoideus
6. B-fracture of pelvis	6. Filiform M2-segment A. cerebri media
7. Teardrop fracture C 2/3	7. Suspicion of small active bleeding thigh
8. Sternal fracture	8. Joint effusion, wrong fracture classification
9. Osseous fragment in optical canal	9. Unclear liver lesion
10. Non-dislocated femoral neck fracture, liver cirrhosis	10. Small avulsion transverse process L 2
11. Dissection of A. fibularis next to fracture	11. Cervical hematoma
12. Blood in ventricles	*12. Assessment compaction (tumor vs. hematoma)*
13. Bilateral vertebral arch fracture C 6	13. More rib fractures with known serial rib fracture
14. Sternal fracture	14. Pulmonary nodule
15. Pulmonary embolism	15. Pulmonary infiltrations
16. Sacral fracture	16. Old myocardial infarction
17. Hemothorax	17. Abdominal wall hematoma
18. Retrosternal hematoma	18. Non-displaced radial head fracture
19. Fracture sacral body 4	19. Active bleeding axilla
20. Fractures thoracic spine	20. Metastasis
21. Fracture Th 12	21. Consolidated fracture Th 11/12
	22. Unclear small liver lesion
	23. Consolidated serial rib fracture

Reporting errors

Overall, 44 (10.7 %) reporting errors were documented. Of those, 47.7 % were relevant findings and 52.3 % were not relevant for further diagnostic or even therapeutic steps. Four out of the 44 affected patients died due to their injuries. However, none of the missed injuries was the cause of death.

A large number of the clinically relevant missed findings were related to the musculoskeletal system (n = 14, 67 %). Among the clinically relevant reporting errors, no interpretation mistakes were found. Clinically less relevant missed findings consisted mainly of soft tissue lesions like hematoma (n = 15, 65 %). Among the clinically less relevant reporting errors, 2 interpretation mistakes were detected. Detailed information is given in ▶ **Table 3**.

▶ **Table 4** summarizes the reporting mistakes of residents and board-certified radiologists. 72.7 % of the mistakes were ascribed to residents. Generally, the percentage of mistakes was higher when no SR was used (12.6 % vs. 8.4 %, $p = .49$). Both, residents and board-certified radiologists had fewer reporting mistakes when using SR with 16.4 % vs. 12.6 % ($p = .10$) and 8.8 % vs. 2.7 % ($p = .45$), respectively. For residents, the rate of clinically relevant mistakes improved slightly when using SR (7.8 % vs. 6.8 %, $p = .79$) and the rate of clinically not relevant mistakes decreased from 8.6 % to 5.8 % ($p = .43$). For board-certified radiologists, the rate of clinically relevant mistakes remained stable at a low level when using SR (2.6 % vs. 2.7 %, $p = .99$) and not clinically relevant mistakes decreased from 6.1 % to 0 % ($p = .03$). In total, significantly fewer mistakes were found in SR reports of board-certified radiologists compared to FTRs of residents ($p = .03$). Altogether, the percentage of reporting mistakes was 13.6 % in reports during on-call duties (8.30 p. m. – 7.00 a. m.) and 10.1 % in daytime reports (7.00 a. m. – 8.30 p. m.). A closer analysis revealed an improvement of reporting errors during the daytime when using SR (12.8 % vs. 6.8 %, $p = .14$). This observation pertained to both clinically relevant and not clinically relevant findings. During on-call duties, the overall error rate increased from 11.8 % to 16.7 % ($p = .90$). Interestingly, not clinically relevant mistakes also decreased from 4.0 % to 3.4 % ($p = .13$) while clinically relevant errors rose from 7.8 % to 13.3 % ($p = .63$) (**Supplement 3**).

▶ **Table 4** Summary of reporting mistakes for residents and board-certified radiologists. Mistakes are classified as "no mistake" (I), "no clinically relevant mistake" (II), and "clinically relevant mistake" (III). SR = structured report; FTR = free-text report; p = p-value for comparison of both clinically relevant and clinically not relevant mistakes with SR vs. FTR (*p < .05 statistically significant).

▶ **Tab. 4** Zusammenfassung der Befundungsfehler bei Weiterbildungsassistenten und Fachärzten. Die Fehler sind aufgeschlüsselt in „kein Fehler" (I), „kein klinisch relevanter Fehler" (II) und „klinisch relevanter Fehler" (III). SR = strukturierte Befundung; FTR = freie Befundung; p = p-Wert für den Vergleich der Anzahl an sowohl klinisch relevanten und nicht klinisch relevanten Befundungsfehlern mit SR vs. FTR (*p < 0,05 statistisch signifikant).

	Residents				Board-certified radiologists				All
	I	II	III	p	I	II	III	p	
FTR	97	10	9	.45	104	7	3	.10	230
SR	90	6	7		73	0	2		178
all	187	16	16		177	7	5		408

▶ **Table 5** Results of the referrer survey, sorted in ascending order in regard to agreement with the statements in the initial survey. A = agreement with the statement, I = importance of this statement, M ± SD = mean±standard deviation. *p-value statistically significant (p < .05).

▶ **Tab. 5** Ergebnisse der Zuweiserbefragung, aufsteigend sortiert nach Zustimmungsgrad in der Vorher-Befragung. A = Zustimmung zu der Aussage, I = Wichtigkeit der jeweiligen Aussage, M ± SD = Mittelwert±Standardabweichung. *p-Wert statistisch signifikant (p < 0,05).

Statement	A before (M±SD)	I before (M±SD)	A after (M±SD)	I after (M±SD)
The reports are comprehensible.	1.4 ± 0.5	1.0 ± 0.2	–	–
Structured reporting makes the reports more comprehensive.	–	–	1.7 ± 1.2	1.3 ± 0.4
In trauma imaging personal discussion of the findings is crucial for me.	1.5 ± 0.9	1.1 ± 0.4	–	–
Despite structured reporting personal discussion of the findings is crucial for me.	–	–	1.0 ± 0.5	1.1 ± 0.3
In general, I am satisfied with the radiology reports.	1.7 ± 0.8	1.1 ± 0.3	1.5 ± 1.1	1.1 ± 0.4
I prefer standardized vocabulary.	1.8 ± 1.0	1.5 ± 0.7	1.5 ± 1.2	1.6 ± 0.8
The reports contain clinically relevant information and they are adequate to derive the right therapeutic steps.	1.9 ± 0.7	1.1 ± 0.3	1.6 ± 0.9	1.3 ± 0.4
Life-threatening and important pathologies can be easily detected in the reports.	2.1 ± 1.2	1.1 ± 0.3	1.6 ± 1.1	1.1 ± 0.3
The trauma reports have a consistent structure.	2.1 ± 1.1	1.3 ± 0.5	1.4 ± 1.1	1.5 ± 0.6
The content of the trauma reports is standardized.	2.2 ± 1.1	1.3 ± 0.5	1.3 ± 1.1*	1.4 ± 0.7
The written trauma report is provided in a timely manner.	2.8 ± 1.1	1.2 ± 0.4	2.1 ± 1.3	1.3 ± 0.6

Referrer satisfaction

Overall, 60 participants answered the initial survey (response rate 16.5 %) and 43 of them were available for further analysis. Survey participants were equally distributed with 12 residents, 15 board-certified radiologists, and 16 senior physicians/clinic directors. From the follow-up survey, 36 responses (response rate 9.9 %) were obtained with only 20 survey results for full analysis. Four of them were made by residents, 7 by board-certified radiologists, and 8 by senior physicians/clinic directors. The remaining participant did not indicate the position. The initial referrer survey revealed good overall satisfaction of 1.7 ± 0.8 (▶ **Table 5**, **Supplement 4**). However, especially in the field of report structure, potential for improvement regarding consistency and provision of reports was identified. After the 6-month implementation of SR, the overall satisfaction improved minimally to 1.5 ± 1.1 in the second survey. All items that had been evaluated as very good improved further. The initial poorer results also improved but mainly did not reach statistical significance. Thus, referrers obviously found it easier to detect life-threatening and important pathologies in the reports with an improvement from 2.1 ± 1.2 to 1.6 ± 1.1 (*p* = .32). Also, reports were rated to have a more consistent structure (2.1 ± 1.1 to 1.4 ± 1.1; *p* = .09) and to be significantly more standardized (2.2 ± 1.1 to 1.3 ± 1.1; *p* = .03). Moreover, as verified by our measurements, the referrers perceived a timelier provision of the reports (2.8 ± 1.1 to 2.1 ± 1.3; *p* = .33).

Discussion

In this study the influence of SR on reporting time and reporting errors was investigated with routine data during an implementation project. Additionally, the benefit of SR was evaluated by means of a referrer survey.

To achieve further standardization, a European guideline was published by the European Society for Emergency Radiology (ESER) in December 2020 [6]. It is the first international guideline with a clear allowance according to communication and reading times of whole-body trauma CT. To comply with this guideline, a three-step approach during image reading is necessary. A primary assessment of the first available series should be performed to identify life-threatening injuries. It is followed by a secondary assessment of all final images within one hour. Within 24 hours, a tertiary assessment by another radiologist is required to reduce missed injuries. Missed injuries should be documented as an addendum. The reporting structure is not covered by the guideline. However, it refers to the guideline of the Royal College of Radiology (RCR), which proposes a checklist for both the primary and secondary assessment [7]. It clearly states that every single institution should develop a fixed protocol or procedure for the interpretation of whole-body trauma CT to minimize the rate of overlooked injuries as well as random findings [6]. Reporting time decreased during implementation of SR with 13 % more finalized reports within one hour as prompted by the new guideline, reaching statistical significance after 4 months. Especially residents improved their reporting times. This finding can partially be explained by the workflow at our institution. Reports that were initially read by a resident and immediately approved by a board-certified radiologist were also included in the group of board-certified radiologists. However, the overall reporting time for board-certified radiologists remained stable with SR. One obstacle to the implementation of SR in the clinical routine is the widespread opinion that it is more time-consuming than reporting in prose style [25]. Usually, the rigidity of SR for secondary findings is mentioned as one of the most time-restricting factors [25–27]. The template used in this study was designed for a full radiology report including a native CT scan of the brain, CT angiography of the head and neck, as well as a scan of the thorax, abdomen, and pelvis. Hence, our findings do not confirm this assumption. Jorg et al. investigated reporting time for SR in trauma CT in an experimental emergency room setting [28]. They found similar results. Their mean reporting time was 19 min. and they only included 14 whole-body CT examinations. Reports in our study took longer which could be caused by the real interruptions during daily work. Only sparse data about the reporting time for routine trauma CT scans is available. According to the national survey of the United Kingdom the vast majority of trauma reports are finalized within two hours [29]. These results correspond with the findings of this study and emphasize the challenge to fully comply with the new European guideline.

The percentage of reporting errors decreased with SR. However, the decrease was not statistically significant. Dendl et al. found contradictory results for board-certified radiologists using a checklist style SR for phase 1 reporting, while the resident in their study improved significantly [30]. These differences have multiple explanations. Firstly, they did not evaluate the reporting errors under real conditions, where interruptions such as phone calls and other examinations occur. Secondly, they only had 3 readers. Our study results stem from one department where radiologists with different levels of experience and expertise in emergency radiology are employed. It can, therefore, be considered as a representative sample. Thirdly, their study aimed to take 10 min. or less for the whole checklist. This study, however, took place during the daily routine and during implementation of SR. All radiologists had to work with the technical possibilities, but they were able to take time and read the CT scans at their own pace. Both our radiologists and the study team of Dendl et al. had to master the very different workflow compared with FTR. In contrast to Dendl et al., our study evaluated a reporting template which includes secondary findings and covers phase 2 reading in accordance with the European guideline. For this reason, we conclude that the implementation of SR can be undertaken safely during the routine workflow without lessening report quality.

Jorg et al. found more detailed diagnoses in SR for whole-body trauma CT examinations in an experimental study setting [28] and concluded that it adds clinical value in comparison to FTR. The quality of SR was rated better than FTR. However, a disadvantage of their study is the evaluation of the reports by radiologists. Value-based radiology aims to create reports that are helpful for the referrer [31]. Therefore, reports should be rated by the recipients. Our referrer survey showed an improvement of the perception of structured whole-body trauma CT reports although the initial satisfaction was already high. Abdellatif and colleagues investigated the needs and expectations of emergency department clinicians [32]. They report similar general satisfaction with radiology reports with rates greater than 90 %. Even with high satisfaction in surveys, SR can be considered a tool for the further improvement of radiology reports and for enhancing referrer satisfaction. Thus, the experience from prior studies about oncological reports can be transferred to SR of whole-body trauma CT examinations.

There are some limitations of this study. Firstly, many results are not significant. As described above, we report real-world data, which is an important step to transfer and verify *in vitro* knowledge into practical application. Thus, we interpret our results as a realistic scale of improvement in the daily routine. Secondly, the study lacks long-term results. Especially in light of the first limitation, long-term data need to be scrutinized to evaluate the value and significance of SR in the daily routine.

Conclusion

In conclusion, SR for whole-body CT in trauma can be implemented safely in the clinical routine. SR facilitates process improvement compared with FTR and results in fewer reporting errors, decreased reporting time, and simultaneously increased referrer satisfaction. A further validation of process improvement over the course of familiarization with SR is warranted.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

[1] World Health Organization. Injuries and violence: the facts, 2014. 2014. Im Internet (Stand: 20.02.2022): https://apps.who.int/iris/bitstream/handle/10665/149798/9789241508018_eng.pdf

[2] Difino M, Bini R, Reitano E et al. Epidemiology of trauma admissions in a level 1 trauma center in Northern Italy: a nine-year study. Updat Surg 2021; 73: 1963–1973. doi:10.1007/s13304-021-00991-y

[3] Candefjord S, Asker L, Caragounis EC. Mortality of trauma patients treated at trauma centers compared to non-trauma centers in Sweden: a retrospective study. Eur J Trauma Emerg Surg 2022; 48: 525–536. doi:10.1007/s00068-020-01446-6

[4] Fiumedinisi FA, Amsler F, Gross T. Short-term outcome following significant trauma: increasing age per se has only a relatively low impact. Eur J Trauma Emerg Surg 2021; 47: 1979–1992. doi:10.1007/s00068-020-01357-6

[5] Huber-Wagner S, Lefering R, Qvick LM et al. Effect of whole-body CT during trauma resuscitation on survival: a retrospective, multicentre study. The Lancet 2009; 373: 1455–1461. doi:10.1016/S0140-6736(09)60232-4

[6] Wirth S, Hebebrand J, Basilico R et al. European Society of Emergency Radiology: guideline on radiological polytrauma imaging and service (short version). Insights Imaging 2020; 11: 135. doi:10.1186/s13244-020-00947-7

[7] The Royal College of Radiologists. Standards of practice and guidance for trauma radiology in severely injured patients, Second edition. 2015.; Im Internet (Stand: 22.09.2020): https://www.rcr.ac.uk/system/files/publication/field_publication_files/bfcr155_traumaradiol.pdf

[8] Deutsche Gesellschaft für Unfallchirurgie e. V. (DGU). S3 – Leitlinie Polytrauma/Schwerverletzten-Behandlung. 2016.; Im Internet (Stand: 22.09.2020): https://www.awmf.org/leitlinien/detail/ll/012-019.html

[9] Deutsche Gesellschaft für Unfallchirurgie e. V. (DGU). Weißbuch Schwerverletztenversorgung. 2019.; Im Internet (Stand: 21.09.2020): https://www.dgu-online.de/fileadmin/dgu-online/Dokumente/6._Versorgung_und_Wissenschaft/Qualität_und_Sicherheit/2019_DGU-Weissbuch_Schwerverletztenversorgung_3._Auflage_FINAL.PDF

[10] Banaste N, Caurier B, Bratan F et al. Whole-Body CT in Patients with Multiple Traumas: Factors Leading to Missed Injury. Radiology 2018; 289: 374–383. doi:10.1148/radiol.2018180492

[11] Geyer LL, Körner M, Linsenmaier U et al. Incidence of delayed and missed diagnoses in whole-body multidetector CT in patients with multiple injuries after trauma; 2013: 592–598. doi:10.1177/0284185113475443

[12] Yoong S, Kothari R, Brooks A. Assessment of sensitivity of whole-body CT for major trauma. Eur J Trauma Emerg Surg 2019; 45: 489–492. doi:10.1007/s00068-018-0926-7

[13] Gruen RL, Jurkovich GJ, McIntyre LK et al. Patterns of Errors Contributing to Trauma Mortality: Lessons Learned From 2594 Deaths. Ann Surg 2006; 244: 371–380. doi:10.1097/01.sla.0000234655.83517.56

[14] Sahni VA, Silveira PC, Sainani NI et al. Impact of a Structured Report Template on the Quality of MRI Reports for Rectal Cancer Staging. Am J Roentgenol 2015; 205: 584–588. doi:10.2214/Am J Roentgenol.14.14053

[15] Schöppe F. Structured reporting adds value to the evaluation of primary staging CT examinations of patients with diffuse large B-cell lymphoma; 2017; 1001 words. doi:10.1594/ECR2017/C-2921

[16] Brown PJ, Rossington H, Taylor J et al. Standardised reports with a template format are superior to free text reports: the case for rectal cancer reporting in clinical practice. Eur Radiol 2019; 29: 5121–5128. doi:10.1007/s00330-019-06028-8

[17] Tersteeg JJC, Gobardhan PD, Crolla RMPH et al. Improving the Quality of MRI Reports of Preoperative Patients With Rectal Cancer: Effect of National Guidelines and Structured Reporting. Am J Roentgenol 2018; 210: 1240–1244. doi:10.2214/Am J Roentgenol.17.19054

[18] Brook OR, Brook A, Vollmer CM et al. Structured Reporting of Multiphasic CT for Pancreatic Cancer: Potenzial Effect on Staging and Surgical Planning. Radiology 2015; 274: 464–472. doi:10.1148/radiol.14140206

[19] Ernst BP, Reissig MR, Strieth S et al. The role of structured reporting and structured operation planning in functional endoscopic sinus surgery. PLOS ONE 2020; 15: e0242804. doi:10.1371/journal.pone.0242804

[20] Buckley BW, Daly L, Allen GN et al. Recall of structured radiology reports is significantly superior to that of unstructured reports. Br J Radiol 2018; 91: 20170670. doi:10.1259/bjr.20170670

[21] Schwartz LH, Panicek DM, Berk AR et al. Improving communication of diagnostic radiology findings through structured reporting. Radiology 2011; 260: 174–181. doi:10.1148/radiol.11101913

[22] Wetterauer C, Winkel DJ, Federer-Gsponer JR et al. Structured reporting of prostate magnetic resonance imaging has the potential to improve interdisciplinary communication. PLOS ONE 2019; 14: e0212444. doi:10.1371/journal.pone.0212444

[23] Lee JK, Bermel R, Bullen J et al. Structured Reporting in Multiple Sclerosis Reduces Interpretation Time. Acad Radiol 2020; 28: 1733–1738. doi:10.1016/j.acra.2020.08.006

[24] Lin E, Powell DK, Kagetsu NJ. Efficacy of a Checklist-Style Structured Radiology Reporting Template in Reducing Resident Misses on Cervical Spine Computed Tomography Examinations. J Digit Imaging 2014; 27: 588–593. doi:10.1007/s10278-014-9703-2

[25] Faggioni L, Coppola F, Ferrari R et al. Usage of structured reporting in radiological practice: results from an Italian online survey. Eur Radiol 2017; 27: 1934–1943. doi:10.1007/s00330-016-4553-6

[26] Pinto dos Santos D, Hempel JM, Mildenberger P et al. Structured Reporting in Clinical Routine. Fortschr Röntgenstr 2019; 191: 33–39. doi:10.1055/a-0636-3851

[27] Ganeshan D, Duong P-AT, Probyn L et al. Structured Reporting in Radiology. Acad Radiol 2018; 25: 66–73. doi:10.1016/j.acra.2017.08.005

[28] Jorg T, Heckmann JC, Mildenberger P et al. Structured reporting of CT scans of patients with trauma leads to faster, more detailed diagnoses: An experimental study. Eur J Radiol 2021; 144: 109954. doi:10.1016/j.ejrad.2021.109954

[29] Smith CM, Mason S. The use of whole-body CT for trauma patients: survey of UK emergency departments. Emerg Med J 2012; 29: 630–634. doi:10.1136/emj.2011.111708

[30] Dendl LM, Pausch AM, Hoffstetter P et al. Structured Reporting of Whole-Body Trauma CT Scans Using Checklists: Diagnostic Accuracy of Reporting Radiologists Depending on Their Level of Experience. Fortschr Röntgenstr 2021; 193: 1451–1460. doi:10.1055/a-1541-8265

[31] European Society of Radiology (ESR). Value-based radiology: what is the ESR doing, and what should we do in the future? Insights Imaging 2021; 12: 108. doi:10.1186/s13244-021-01056-9

[32] Abdellatif W, Ding J, Hussien AR et al. Evaluation of Radiology Reports by the Emergency Department Clinical Providers: A Message to Radiologists. Can Assoc Radiol J 2020; 72: 533–540. doi:10.1177/0846537120902067