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Remote Out-of-hours Ultrasound Live Supervision in Pediatrics – Improvement of Diagnostics and Training

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Abstract:

Purpose: Ultrasound (US) is the preferred imaging modality in pediatrics for diagnostic and therapeutic issues. The absence of radiation and the constant on-site accessibility make it the ideal tool for children. However, despite remarkable technical advances in resolution and applicability, many sophisticated medical questions still require profound expertise of the examiner often hampering fast decisions particular outside regular working hours.

Materials and Methods: This single-center study, at a university children's hospital evaluated the use of an US during emergency-service. Four-week documentation period was followed by a subsequent eight-week supervision period with live supervision availability on demand guided by a remote US expert. The demand for expertise support, diagnosis, grading of urgency, duration and success of examination and satisfaction of both examiners were analyzed.

Results: 108 patients (mean age 9.7years) were included. In 38% of cases US was supervised on demand with a definite diagnosis in 92.6% (25/27). Image quality and technical performance were graded sufficient in 100%. Supervised compared to non-supervised US examinations were prolonged (14.4 min vs. 7.1 min, $p<0.001$), were more prevalent within the first 24 h in hospital (70% vs. 56.8%, $p=0.06$) and were classified more frequently as emergency (22.2% vs. 2.3%; $p=0.015$). All participants classified the availability of a US-supervision as decisively helpful.

Conclusion: Remote live supervised pediatric US was feasible and effective. It combined timely, high-quality diagnostics of even challenging medical questions with a simultaneous US training.

Hintergrund: Pädiatrischer Ultraschall (US) ist die bevorzugte Bildgebung für diagnostische und therapeutische Fragen und aufgrund von Strahlenfreiheit und ständiger Verfügbarkeit vor Ort ideal. Trotz großer technischer Fortschritte bei Bildauflösung und Anwendung erfordern schwierige Fragen eine profunde Expertise, was eine zeitnahe Diagnostik, vor allem im Notdienst, oft erschwert.

Materialien und Methoden: Eine unizentrische Studie an einer Universitäts-Kinderklinik bezüglich US-Untersuchungen im Notdienst wurde ausgewertet. Einer 4-wöchigen Beobachtungsphase folgte eine 8-wöchige Supervisionsphase mit Möglichkeit zur Anforderung einer Live-Supervision aus der Ferne durch einen US-Experten. Analysiert wurden der Bedarf an fachlicher Unterstützung, die Diagnose, die Dringlichkeit, die Dauer, der Erfolg sowie die Zufriedenheit der Untersucher.

Ergebnisse: 108 Kinder (Ø 9,7 Jahre) wurden eingeschlossen. 38% aller US-Untersuchungen wurden auf Wunsch live supervidiert und dabei in 92,6% (25/27) der Fälle eine Diagnose gestellt. Die Bildqualität und die technische Umsetzung waren immer ausreichend. Supervidierte Untersuchungen dauerten länger (14,4 min vs. 7.1 min, $p<0.001$), erfolgten häufiger innerhalb 24h

Klinikaufenthalt (70% vs. 56.8%, $p=0.06$) und wurden häufiger als Notfall eingestuft (22.2% vs. 2,3%; $p=0.015$). Die Supervisionsmöglichkeit wurde von allen Teilnehmern als entscheidend hilfreich eingeordnet.

Schlussfolgerung: Live aus der Distanz supervidiertes pädiatrisches US war effektiv, ermöglichte eine zeitnahe, qualitativ hochwertige Diagnostik auch bei schwierigen medizinischen Fragestellungen und war zeitgleich hilfreich für die US-Ausbildung.

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1 Introduction

2 Ultrasound (US) technology is an indispensable tool in diagnostics, interventions and to monitor
3 therapy success. Its advantages include noninvasiveness, absence of ionizing radiation, fast and
4 throughout availability, cost-effectiveness and latest technologies (microvascular imaging) providing
5 the most advanced medical imaging [1,2]. US diagnostics is particularly suitable for the use in children
6 due to the non-requirement of sedation and excellent image resolution given their slender body
7 composition [3,4]. The use of point-of-care US (POCUS) in pediatric emergency departments
8 demonstrates these advantages in acute, time-sensitive medical challenges [5,6,7,8] and efforts have
9 been made to standardize recommendations for pediatric POCUS application as exemplified by the
10 ESPNIC (European Society of Paediatric and Neonatal Intensive Care) evidence-based guidelines [9].
11 Examiner expertise is of utmost importance and different approaches to enhance US knowledge such as
12 peer-assisted abdominal US teaching, training with US body part models, and task-trainer computer-
13 based US simulation demonstrated the ability to improve US expertise [10,11,12]. Recently a
14 nationwide accredited pediatric-specific curriculum and training plan for POCUS application in the UK
15 (CACTUS – Children’s ACuTe UltraSound) was published to address the lack of standardization of
16 POCUS curricula, qualification and certification [13]. Further challenges and obstacles are new fields
17 for POCUS application, ensuring of POCUS application skills, shortage of certified instructors and on-
18 site devices [3,4,7,9,13,14,15,16].

19 Remote US supervision appears to be a promising approach to address these POCUS challenges.
20 Remote teaching has proven to be as effective as on-site teaching [17,18,19,20] and first feasibility
21 studies simulated various clinical challenges for lung, cardiac and pediatric POCUS involving
22 physicians and prehospital staff [21,22,23,24]. These studies focused on technical feasibility,
23 supervisor accessibility, expenditure of time, US functionality and patient-self performance
24 [21,22,25,26]. However, poor network quality resulting in prolonged and delayed exams, restriction to
25 simple medical or trauma-related questions and mandatory on-site attendance of an US expert [27] limit
26 in part their overall significance.

27 In this study we analyze the general demand and technical feasibility of 24/7 remote US support at a
28 tertiary University Children`s Hospital. Further, we evaluated the impact on patient care and US
29 education.

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30 **Material and Methods**

31 **Patient Recruitment and Data Collection**

32 This single-center study was conducted between October 2022 and January 2023 at a tertiary
33 University Children`s Hospital. We included all US exams performed on outpatients of the central
34 emergency department and on inpatients of the pediatric wards. The pediatric and neonatal intensive
35 care unit were excluded due to reduced accessibility to the specialized US device due to a longer
36 distance to the US department. US exams performed during regular working hours were not part of this
37 study design as on-site US supervisors are available and can immediately assist or take-over US exam
38 in case of difficult medical questions and technical challenges.

39 Documentation of US exams was standardized and included the following parameters: name of on-site
40 examiner, patient, date and time of exam, medical problem as reason for US exam, grading of urgency
41 (emergency, urgent and standard), success of exam (technical performance, achievement of definite
42 diagnosis, duration of exam, clinical consequence (yes/no)) (**Suppl. 1,2,3**). Clinical consequences
43 designated as “yes” were further defined as a direct consequence of the performed US exam and could
44 be decisions to perform surgery (e.g. appendectomy) or an intervention (e.g. placement of a pleural
45 drain), decisions on further diagnostics (e.g. other form of imaging) and decisions to restart or change a
46 therapy (e.g. start antibiotic therapy).

47 The first four weeks of the study phase served as “documentation period” to assess the demand of
48 remote live US supervision; Examiners documented for each US exam whether live supervision would
49 have been requested if available.

50 During the following eight weeks (referred to as “supervision period”) examiners had the possibility to
51 request a remote supervision by a pediatric US expert for each US exam. The need and the technical
52 implementation for supervision, name of remote supervisor and the satisfaction of on-site examiners
53 and supervisors were documented.

54 Basic US expertise with proof of at least 700 US exams performed during the training period is a
55 precondition for acquisition of specialist certification in pediatrics in Germany. The physicians-on-duty
56 taking part in this study were at least in their 5th year of residency after completion of a standardized 3-
57 months US training including about 2000 pediatric US exams performed under supervision of certified
58 pediatricians. The remote supervision was performed by five different senior pediatricians certified in
59 pediatric ultrasonography by the German Society for US in Medicine (DEGUM). Three supervisors
60 were certified as DEGUM level 1 with proof of certified training in pediatric sonography e.g. by
61 participation in a DEGUM-certified pediatric basic and advanced course, proof of 850 independently
62 performed US exams including brain, abdomen and hips and successful practical exam. Two
63 supervisors were certified as DEGUM level 2 with proof of at least 3 years of experience in pediatric
64 US, 1800 independently performed US exams including brain, abdomen and hips and successful exam
65 regarding teaching ability on the basis of lectures.

66 All attending physicians received a simulator-based training before the start of the study.

67

68 **Standard US Exams**

69 US exams were performed using an Aplio i800 (Canon Medical Systems) with transducers of different
70 frequencies (i8CX1, I18LX5, I22LH8 and PVT712BT). A high-quality HDMI to USB 3.0 video
71 encoder (Roland UVC-01) was attached to the US device to facilitate image live streaming with
72 uncompressed 1080p HD at 60 FPS. This video capture device was connected to a laptop with high-
73 resolution imaging including a 2560-by-1664 native resolution at 224 pixels per inch (MacBook Air

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74 M2 with 13.6-inch (diagonal) LED-backlit display) as shown in **Fig. 1**. The wireless local area network
75 (WLAN) was used for image transmission; a virtual classroom software program designed for online
76 education (Big Blue Button) ensured livestream imaging and continuous bilateral communication
77 between supervisor and on-site examiner in a high-definition setting (1080p video mode, 1,920 by 1080
78 pixels). Regarding data safety, patient data were de-identified before start of the livestream and the
79 software program was password-protected. All images and documentation reports of US exams have
80 been stored automatically in the internal imaging system.

81

82 **Questionnaire**

83 An anonymous on-line evaluation (Lime Survey) among all attending physicians was conducted after
84 completion of the study. The questionnaire contained 21 questions. Questions 1-7 requested the general
85 level of training and the US experience. Questions 8-13 referred to personal confidence with regard to
86 their US expertise, particularly in on-duty situations. Questions 14-20 were related to the remote live
87 supervision offered within this study and Question 21 inquired the need for instructional videos on
88 various US topics. Further detailed information is depicted in **Suppl. 4 and 5**.

89

90 **Patient data**

91 We evaluated the age, sex and discharge diagnosis of all patients.

92

93 **Ethics**

94 The local ethics committee approved the study. Written informed consent was not required, as de-
95 identification during live streaming was part of the protocol. Before enrolment, all participants
96 respectively their parents or legal guardians gave their oral informed consent.

97

98 **Statistical analyses**

99 The statistical tests were conducted using R-Studio (Version 2023.09.0 Build 463) and Instant Clue
100 (Version 0.12.1). The raw ordinal data transformed into percentage of the respective group and
101 statistically analyzed using the Chi-square test with Yates' continuity correction if needed. The metric
102 data were analyzed by an unpaired Student's t-test. In both tests, p-values below 0.05 were considered
103 significant.

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104 **Results**

105 **Pediatric cohorts**

106 This study included 1247 inpatients (documentation period n=432; supervision period n=815) and 1704
107 patients in the central emergency department (CED) (documentation period n=528; supervision period
108 n=1176). Oncological and pneumological diseases were the most frequent inpatient diagnoses,
109 diagnoses groups did not differ significantly (inpatients p=0.31 resp. CED p=0.99) between the two
110 periods. **(Tab. 1, Suppl. 6).**

111 Main reasons for presentation to the CED were fever and discomfort with no significant differences
112 between the analyzed time-periods (52.8% vs. 47.4%) **(Suppl. 6)**. CED patients were classified
113 according to the Manchester Triage System (MTS) and the proportion of patients who proceeded to
114 hospital admission was not statistically significantly different between both periods (p=0.92 and
115 p=0.969).

116

117 **US exams in the documentation and supervision period**

118 This study included overall 108 US exams and the average number of US exams was equal between the
119 documentation and supervision period (1.3 exams/day).

120 During the documentation period the physicians on-duty indicated a desire for supervision support in
121 54.1% of all US examinations, the rate of supervisions requested during the supervision period was
122 38% (27/71).

123 Supervised US exams required more time (14.4 min vs. 7.1(without supervision) resp. 9.9
124 (documentation period) min; p<0.01 resp. p=0.08), were performed more frequently within the first 24
125 hours of presentation (70.4% vs. 56.8%, p=0.06), and were categorized more frequently as urgent
126 (“emergency”; 22.2% vs. 2.3% resp. 10.8%; p<0.001) compared to non-supervised US exams. The
127 proportion of exams performed at night was higher in the supervision period (28.2% vs. 16.2%;
128 p=0.015) **(Tab. 2)**.

129 The main reasons for initiating a POCUS exam were pain and/or swelling in a specific area of the body
130 (abdomen, thorax, neck, genitals), abnormal parameters of blood and urine (kidney and/or liver
131 enzymes, blood gas analysis, urine analysis), traumatic injury or surgical procedure. Abdominal US
132 exams were most frequent (43.3-68.9%). In almost half of the POCUS exams, a suspected pathology
133 was excluded (42.6% – 50.0%) as presented in **Suppl. 7**. Pathological US findings were most
134 frequently related to the gastrointestinal system (18.5%-28.0%; in particular gastroenteritis,
135 appendicitis, liver anomalies). Supervised US exams included a higher proportion of specific request
136 areas and partly findings such as kidney (20%; focal nephritis, renal transplant perfusion, chronic
137 kidney failure, nephrolithiasis, urinary tract disorder), cervical area (10%; parotitis, lymphadenitis,
138 exclusion abscess cervical region), testis (6.7%; epididymitis, testicular torsion) and lung (6.7%;
139 pneumonia and pleural effusion) **(Suppl. 7; Fig. 2,3,4,5; Video 1)**.

140 In 25 of 27 (92.6%) of supervised US exams a diagnosis was confirmed or ruled out by the on-site
141 examiner and the supervisor without subsequent revision by other investigators **(Suppl. 8)**.

142 Clinical consequences after an US exam leading to a surgical (e.g. appendectomy, orchidopexy,
143 vascular revision) or interventional procedure (e.g. bladder catheterization, kidney biopsy, stone
144 removal, pleural drainage) evolved in 22 of 117 (18.8%) of cases and were similar in both periods and
145 not increased in supervised exams (17.9 – 20.0%, p=0.17). However, initiation or change of drug
146 therapy (mainly antibiotics and laxative drugs) were lower in non-supervised compared to supervised

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147 US exams and during the documentation period (11.6% vs. 25.7% resp. 33.3%, p=0.018 resp.
148 p<0.001). Details are listed in **Suppl. 7**.

149 **Questionnaire**

150 **Demographics**

151 Fifty-eight physicians completed the questionnaire. All supervisors and 25% of senior pediatric
152 physicians, but only 5.3% of pediatric specialists and none of the residents were DEGUM level 1
153 certified.

154 Supervisors and residents during/after US rotation (40% resp. 33.3 %) attended a certified US course by
155 DEGUM more frequently than pediatric specialists (0%) and residents waiting for US rotation and
156 senior pediatric physicians (each 6.3%) (**Suppl. 9**).

157 **US exams**

158 All supervisors, 15.8% of pediatric specialists and 37.6% of senior pediatric physicians performed US
159 exams at least several times (defined as ≥ 3 US exams) a week., whereas 58.3% of residents before US
160 rotation and 37.5% of senior pediatric physicians did not perform US on a regular basis.

161 All supervisors, but only 12.1% of the remaining cohort of attending physicians indicated to feel
162 confident to perform pediatric US exams without supervision. Confidence was higher among
163 physicians performing US routinely (≥ 3 times/week (40% vs. 3.7%/ 0% [performed less
164 frequently/never]).

165 None of the supervisors, but overall 32.8% of the other participants postponed US exams due to lack of
166 time and with higher rates in less frequent (80.8%) and “nearly never” (66.6 %) US performers.
167 Uncertainty about missing out pathological findings led to US exam postponements in 39.7% of all
168 examiners, again with higher rates in less frequent US performers, absence of DEGUM 1 level and
169 absence of US rotation (**Tab. 3**).

170 **US supervision**

171 All supervised US exams were classified as decisively helpful to confirm diagnosis and nearly all of
172 them (88.9 %) for training purposes (**Tab. 2**). All physicians supported its further continuation (**Suppl.**
173 **10**). There were no concerns by on-site examiners regarding technical implementations, expectations of
174 the remote supervisor, time-consuming US exams during on-duty shift and demanding the supervisor
175 during night-time. Supervisors assessed practical implementation by on-site pediatricians as very good
176 in all cases and connection quality all of supervised exams were rated as acceptable (**Suppl. 8**). A
177 majority of the participating physicians (**Suppl. 11**) supported the development of short educational
178 videos.

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179 **Discussion**

180 Remote live US supervision was demonstrated to be feasible without any technical restrictions and
181 valuable to train and support physicians at all experience levels particularly in the out-of-hour context
182 and may have an impact to improve US diagnostics even in case of critical pediatric challenges in
183 tertiary hospitals.

184 Only limited pediatric experience in remote US supervision is available. Whitney et al. reported remote
185 pediatric emergency US by an on-site and additionally a remote US expert instantly evaluating
186 downloaded US video clips. However, this and further remote studies demonstrated limitations as lack
187 of availability of supervision experts, reduced effectiveness in prehospital settings and insufficient
188 frame rates per seconds during video [21,23,25,27]. Therefore, our study design relied on WLAN, 24/7
189 support and multiple US supervisors.

190 Survey results and the high rate of supervised US exams strongly indicated the high demand for
191 assistance of on-site pediatricians. Lack of personal experience, time and concerns regarding
192 potentially missed pathologies were frequent worries in our and other studies [7] and led to a proportion
193 of 81 % of pediatricians that postponed US exams.

194 The higher proportion of emergency cases, requests within the first 24 hours of presentation and related
195 to more specific exams underline the importance of supervised US exams. Although supervised US
196 exams as in other studies [21] lasted significantly longer possibly due to complex medical requests,
197 additional use of advanced technologies and simultaneous US training, on-site pediatricians did not
198 consider exam duration as potential barrier. 24/7 remote live supervision option might have led to an
199 increased rate of nighttime US exams in the supervision period, which might potentially accelerate the
200 time to diagnosis.

201 Remote assistance supported various pediatric POCUS challenges and included state-of-the art US
202 techniques such as microvascular imaging for detection of focal nephritis or evidence of adequate
203 perfusion after kidney or liver transplantation, which have not yet been included in POCUS curricula [9,13,24,25,27]. New applications can facilitate and alter medical decisions as demonstrated in a study
204 about the use of pediatric lung POCUS instead of chest radiography leading to a reduction of x-ray
205 exams but also to an increase of antibiotic therapy as US was highly sensitive to detect lung
206 consolidations [28]. Our evaluation did not increase the number of surgical or interventional
207 procedures, but reduced modifications of drug therapy and admission rates during the supervision
208 period.
209

210
211 Our study demonstrated no difficulties regarding the implementation of instructions and expectations
212 of the supervisors probably due to the monocentric study design and the higher rate of participating on-
213 site examiners with intensive pre-study on-site US teaching (50%) compared to other studies displaying
214 difficulties implementing supervisor instructions [14,22,25]. A potential future multicenter approach
215 for remote live US supervision may further emphasize the need for certified pediatric POCUS
216 curricula, training plans and accreditation processes as already started by the ESPNIC in guidelines
217 recommendations and in the UK as part of the CACTUS training [5,6,8,9,13,14].
218

219 **Limitations**

220 The study design includes important limitations such as short study duration, unicentric approach and
221 limited number of US exams. The neonatology and pediatric intensive care and US exams during
222 working hours were excluded. Randomization regarding patient cohorts or examiner experience was

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223 not applied. A multicenter approach as previously discussed might be more challenging due to
224 variations of technical equipment, on-site examiner US experience and pediatric cohorts.

225

226 **Conclusion**

227

228 Remote live US supervision is feasible and effective even in case of various, complex pediatric
229 challenges, and outside regular working hours. It attenuates main obstacles like the shortage of
230 qualified instructors and provides simultaneous US teaching and diagnosis of acute medical demands.
231 Further multicentric studies focusing on patient-centered outcome measures are important to establish
232 and implement respective algorithms for the daily routine.



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Supplement 10: Survey regarding ultrasound supervision

Supervision support for clinical challenge	Percentage
Very helpful	31.0 % (n=18/58)
Helpful	8.6 % (n=5/58)
Limited helpful	0 % (n=0/58)
Not helpful	0 % (n=0/58)
Not participated	53.4 % (n=31/58)
Not specified	6.9 % (n=7/58)
Supervision support for own ultrasound education	
Very helpful	22.4 % (n=13/58)
Helpful	12.1 % (n=7/58)
Limited helpful	0 % (n=0/58)
Not helpful	0 % (n=0/58)
Not participated	53.4 % (n=31/58)
Not specified	12.1 % (n=7/58)
No supervision applied due to concerns about technical implementation	
yes, several times	0 % (n=0/58)
yes, sporadically	0 % (n=0/58)
No	43.1 % (n=25/58)
Not participated	46.6 % (n=27/58)
Not specified	10.3 % (n=6/58)
No supervision applied to avoid night call	
yes, several times	0 % (n=0/58)
yes, sporadically	12.10 % (n=7/58)
No	29.3 % (n=17/58)
Not participated	44.8 % (n=26/58)
Not specified	13.8 % (n=8/58)
No supervision applied due to worries about fulfilling supervisors expectations and instructions	
yes, several times	0 % (n=0/58)
yes, sporadically	3.4 % (n=2/58)
No	37.9 % (n=22/58)
Not participated	41.4 % (n=24/58)
Not specified	17.2 % (n=10/58)
No supervision applied due to supervision duration and pending duty tasks	
yes, several times	0 % (n=0/58)
yes, sporadically	6.9 % (n=4/58)
No	34.5 % (n=20/58)
Not participated	43.1 % (n=25/58)
Not specified	15.5 % (n=9/58)
Supervision of ultrasound examinations should be established after project end	
yes	34.5 % (n=20/58)
Yes and also during normal working hours	51.7 % (n=30/58)
Possibly	3.4 % (n=2/58)

No	0 % (n=0/58)
Not specified	10.3 % (n=6/58)



Supplement 11: Survey results regarding potential instructional videos

Instructional videos	Percentage
Selecting patient data and transducer	39.7 % (n=23/58)
Selecting the right preset	37.9 % (n=22/58)
Image optimization	56.9 % (n=33/58)
Proper saving of images and videos	44.8 % (n=26/58)
Application Doppler Sonography	63.8 % (n=37/58)
Application Microvascular Imaging	62.1 % (n=36/58)
Application Elastography	56.9 % (n=33/58)
Sonographic procedure for the most important and most frequent medical questions in duty situations	79.3 % (n=46/58)

Supplement 6: Pediatric cohort in the central emergency department

	Study period (12 weeks)	Documentation period (4 weeks)	Supervision period (8 weeks)
Patients	1704	528	1176
Sex			
m	53.1 % (n=901)	52.9 % (n=278)	53.2 % (n=623)
f	46.9 % (n=796)	47.1 % (n=248)	46.8 % (n=548)
Age (years)	6.4 ±5.3 (4.8; 0-18)	6.6 ± 5.7 (4,6; 0 -18)	6.4 ±5.2 (4.8; 0-18)
Symptoms	1653	513	1140
General (Fever,Discomfort Worried parents, Consil, Representation)	51.1 % (n=845)	47.4 % (n=243)	52.8 % (n=602)
Pneumology	13.3 % (n=220)	12.7 % (n=65)	13.6 % (n=155)
Gastroenterology	9.9 % (n=163)	13.1 % (n=67)	8.2% (n=96)
Neurology	5.1 % (n=84)	5.7 % (n=29)	4.8 % (n=55)
Accidents	4.8 % (n=79)	4.5 % (n=23)	4.9 % (n=56)
Infectiology	3.8 % (n=62)	4.9 % (n=25)	3.2 % (n=37)
ENO/Dentology	3.6 % (n=59)	2.7 % (n=14)	3.9 % (n=45)
Nephrology/ Urology	2.7 % (n=44)	3.1 % (n=16)	2.5 % (n=28)
Dermatology	2.1 % (n=35)	3.1 % (n=16)	1.7 % (n=19)
Cardiology	0.7 % (n=12)	1.0 % (n=5)	0.6 % (n=7)
Psychology	0.5 % (n=9)	0.6 % (n=3)	0.5 % (n=6)
Others (e.g. Orthopedics, Endocrinology)	2.5 % (n=41)	1,4% (n=7)	3.0 % (n=34)
Referring Institution			
Patient self-referring	68.1 % (n=1160)	70.1 % (n=370)	67.2 % (n=790)
Ambulance car	12.5 % (n=213)	11.6 % (n=61)	12.9 % (n=152)
Family doctor	4.5 % (n=77)	5.7 % (n=30)	4.0 % (n=47)
Internal clinic	6.6 % (n=113)	5.7 % (n=30)	7.1 % (n=83)
External clinic	0.8 % (n=14)	0.9 % (n=5)	0.8 % (n=9)
Other	7.5 % (n=127)	6.1 % (n=32)	8.1 % (n=95)
Triaging			
red	1.8 % (n=30)	1.3 % (n=7)	2.0 % (n=23)
orange	12.5 % (n=213)	14.8 % (n=78)	11.5 % (n=135)
yellow	22.7 % (n=386)	23.1 % (n=122)	22.4 % (n=264)
green	54.1 % (n=922)	53.6 % (n=283)	54.3 % (n=639)
blue	9.0 % (n=153)	7.2 % (n=38)	9,8 % (n=115)
Further treatmet			
Inpatient admission	26.9 % (n=459)	25.6 % (n=135)	27.6 % (n=324)
Outpatient care	66.4 % (n=1131)	68.6 % (n=362)	65.4 % (n=769)
External transfer	2.8 % (n=48)	2.7 % (n=14)	2.9 % (n=34)
Other	3.9 % (n=66)	3.2 % (n=17)	4.2 % (n=49)

Supplement 7: Ultrasound examinations regarding type, diagnosis and consequence

	Documentation period (4 weeks)	Supervision period (without supervision)	Supervision period (including supervision)
Ultrasound type			
Abdominal	66.7 % (n=28/42)	68.9 % (n=31/45)	43.3 % (n=13/30)
Kidney	9,5 % (n=4/42)	13.3 % (n=13/45)	20 % (n=6/20)
Cranial	9,5 % (n=4/42)	6.7 % (n=3/45)	10 % (n=3/30)
Lung	7.1 % (n=3/42)	2.2 % (n=1/45)	6.7 % (n=2/20)
Cervical	4.8 % (n=2/42)	4.4 % (n=2/45)	10 % (n=3/20)
Hip/Inguinal	2.4 % (n=1/42)	2.2 % (n=1/45)	3.3 % (n=1/20)
Testis	0 % (n=0/42)	2.2 % (n=1/45)	6.7 % (n=2/20)
Ultrasound diagnosis			
Exclusion Anomalies	42.6 % (n=23/54)	50.0 % (n=25/50)	48.6 % (n=17/35)
	Brain anomalies n=1 Any abdominal anomalies n=3 Appendicitis n=7 Postoperative abdominal hematoma n=1 Hepatic veno-occlusive disease n=1 Liver transplantation perfusion n=1 Nephritis n=1 Kidney abscess n=2 Nephrolithiasis n=1 Ovarian torsion n=1 Coxitis n=1 Pleural effusion n=1 Pathological Transcranial Doppler Sonography (TCD) n=1	Brain anomalies n=3 Any abdominal anomalies n=3 Appendicitis n=3 Ascites n=7 Kidney abscess n=1 Urinary Tract Disorder/retention n=2 Correct position of ureteral stent n=1 Splenic sequestrum n=1 Inguinal hernia n=1 Cervical abscess n=1 Cervical vascular dissection n=1 Correct position of ventriculoperitoneal shunt drainage n=1	Brain anomalies n=3 Appendicitis n=3 Kidney abscess/focal nephritis n=2 Nephrolithiasis, nephrocalcinosis n=2 Urinary Tract Disorder/retention n=1 Kidney tumor n=1 Volvulus n=1 Liver transplantation perfusion n=1 Testicular torsion n=1 Ovarian torsion n=1 Thrombosis inguinal vein due to shaldon catheter n=1
Gastroenterology/Liver	18.5 % (n=10/54)	28.0 % (n= 14/50)	22.9 % (n=8/35)
	Hepatosplenomegaly n=4 Gastroenteritis n=2 Liver fibrosis n=2 Increased echogenicity of pancreas n=2	Gastroenteritis n=4 Constipation n=4 Appendicitis/Colitis n=2 Splénomegaly n=1 Liver fibrosis n=1 Hepatic veno-occlusive disease n=1 Circulation pattern compatible with acute hepatic failure n=1	Constipation n=3 Appendicitis n=1 Hepatosplenomegaly n=1 Hepatitis n=1 Liver fibrosis n=1 Hepatic transplant artery thrombosis n=1
Lung	5.6 % (n=3/54)	0 %	11.4 % (n=4/35)
	Pleural effusion n=3		Pneumonia and Pleural empyema n=1 Pleural effusion n=2 Pulmonary oedema n=1
Kidney / Urinary Tract	14.8 % (n=8/54)	12.0 % (n=6/50)	17.1 % (n=6/35)
	Cystitis n=3 Postoperative fluid retention n=2 Acute renal failure n=1 Urinary Tract Disorder/retention n=2	Urinary Tract Disorder/ Retention n=6	Pyelonephritis (urothel sign) n= 1 Nephrolithiasis n=1 Urinary Tract Disorder/retention n=1 Chronic renal failure due to renal dysplasia n=1 Kidney tumor n=1 Improved renal transplant perfusion after surgical hematoma removal n=1
Brain	3.7 % (n=2/54)	0 %	0 %
	Extension of external cerebrospinal fluid space n=1 Brain contusion n=1		
Other	14.8 % (n=8/54)	10 % (n=5/50)	28.6 % (n=10/35)
	Ascites n=5 Lymphadenopathy n=2	Ascites n=1 Lymphadenopathy n=1	Ascites n=2 Lymphadenopathy n=2

	Pericardial effusion n=1	Testicular hydrocele n=1 Ventriculoperitoneal shunt drainage fault n=1 Infection of the operative scar n=1	Ovarian cyst hemorrhage n=2 Testicular torsion n=1 Epididymitis n=1 Parotitis n=1 Inguinal hematoma n=1
Consequence			
Intervention	17.9 % (n=7/39) Surgical intervention n=3 Bladder catheterization n=1 Kidney biopsy n=1 Pleural drainage n=1 MRI scan n=1	18.6 % (n=8/43) Bladder catheterization n=3 Appendectomy n=2 Surgical revision of Ventriculoperitoneal shunt n=1 Further investigation (acute liver failure, polydipsia) n=2	20 % (n=7/35) Appendectomy n=2, Kidney stone removal n=1 Surgical revision hepatic transplant artery thrombosis n=1 Orchidopexy n=1 Fibrinolysis through pleural drainage n=1 CT scan n=1
Drug administration	33.3 % (n=13/39) antibiotic therapy n=10 laxative measures n=3	11.6 % (n=5/43) antibiotic therapy n=2 laxative measures n=2 Defibrotide for hepatic veno-occlusive disease n=1	25.7 % (n=9/35) antibiotic therapy n=7 laxative measures n=1 diuretic therapy n=1
Other	48.7 % (n=19/39) Denial for intervention n=8 Outpatient care possible n=3 Follow-up recommended n=8	69.8 % (n=30/43) Denial for intervention n=15 Outpatient care possible n=11 Follow-up recommended n=4	54.3 % (n=19/35) Denial for intervention n=11 Outpatient care possible n=4 Follow-up recommended n=4

Supplement 8: Ultrasound examinations regarding supervisor assessment

Ultrasound diagnosis determination	
Yes	92.6 % (n=25/27)
No	7.4.% (n=2/27)
On-site implementation	
Very good	100 % (n=27/27)
Acceptable	0 % (n=0/27)
Unacceptable	0 % (n=0/27)
Connection quality	
Very good	77.8 % (n=21/27)
Acceptable	22.2 % (n=6/27)
Unacceptable	0 % (n=0/27)
Speed Download (Mbit/s)	62.3 ± 143.5 (24.8; 3.7 - 777)
Speed Upload (Mbit/s)	24.3 ± 30.9 (9.2; 0.7 - 91)

Supplement 9: Survey results regarding physicians group

Physician classification	Percentage
Supervisor	8,6 % (n=5/58)
Resident during intensive care rotation	1,7 % (n=1/58)
Resident during/after ultrasound rotation	10,3 % (n=6/58)
Pediatric specialist	32,8 % (n=19/58)
Senior/ Chief pediatric physician	27,6 % (n=16/58)
Resident before ultrasound rotation	19,2 % (n=11/58)
Ultrasound rotation (>2 months) received	
Yes	50 % (n=29/58)
No	50 % (n=29/58)
Knowledge about DEGUM multi-level concept for pediatrics available	
Yes	72,4 % (n=42/58)
No	24,1 % (n=14/58)
Not specified	3,4 % (n=2/58)
DEGUM level 1 for pediatrics certified	
Yes	17,2 % (n=10/58)
No	81,0 % (n=47/58)
Not specified	1,7 % (n=1/58)
DEGUM ultrasound course attended	
within the last 2 years	6,9 % (n=4/58)
within the last 3 to 5 years	8,6 % (n=5/58)
more than 5 years ago	25,9 % (n=15/58)
never attended	58,6 % (n=34/58)
Practiced on ultrasound phantoms	
Yes	17,2 % (n=10/58)
No	77,6 % (n=45/58)
Not specified	5,2 % (n=3/58)

Documentation US-Streaming Physician on duty (Mon-Fri 17-8, Sat/Sun/PH 8-8) **Status period Date** ____ . ____ . ____

Ultrasound performed

	Name Examiner	2. experienced examiner in attendance consulted (Name)	Time	Surname	Question (Example Abdominal pain -> Abdomen Oxygen saturation drop ->Pleura)	Urgency (1 Emergency 2 urgent 3 not urgent)	Consequence (e.g. change of therapy, further diagnostics -> e.g. other imaging, consultation, intervention)	Online supervision would be desirable (1 yes, 2 no)
1								
	Free text							
2								
	Free text							
3								
	Free text							
4								
	Free text							

Sonography requested but **NOT PERFORMED** due to lack of presence/online supervision

	Name Examiner	Time	Surname	Question (Example Abdominal pain -> Abdomen Oxygen saturation drop ->Pleura)	Urgency (1 Emergency 2 urgent 3 not urgent)	Consequence (e.g.: wait and see and sonography later Alternative diagnostics -> CT, MRI, laboratory diagnostics)
1						
	Free text					
2						
	Free text					
3						
	Free text					
4						
	Free text					
5						
	Free text					

Documentation US-Streaming

Physician on duty (Mon-Fri 17-8, Sat/Sun/PH 8-8)

Online Supervision Date ____ . ____ . ____

Ultrasound performed **without online supervision**

	Name Examiner	2. experienced examiner in attendance consulted (Name)	Time	Surname	Question (Example Abdominal pain -> Abdomen Oxygen saturation drop ->Pleura)	Urgency (1 Emergency 2 urgent 3 not urgent)	Consequence (e.g. change of therapy, further diagnostics -> e.g. other imaging, consultation, intervention)
1							
	Free text						
2							
	Free text						
3							
	Free text						
4							
	Free text						

Ultrasound performed **with online supervision**

	Name Examiner	2. experienced examiner in attendance consulted (Name)	Time	Surname	Question (Example Abdominal pain -> Abdomen Oxygen saturation drop ->Pleura)	Urgency (1 Emergency 2 urgent 3 not urgent)	Consequence (e.g. change of therapy, further diagnostics -> e.g. other imaging, consultation, intervention)	Online supervision helpful (medical question) yes / no	Online supervision helpful (US training) yes / no
1									
	Free text								
2									
	Free text								
3									
	Free text								
4									
	Free text								

Documentation US-Streaming SUPERVISOR „ONLINE-SUPERVISION“ Date ____ . ____ . _____
Supervised sonography

	Super visor	Examiner on site (if Applicable>1)	Time Start	Name Patient	Diagnosis confirmation (Yes/No)	Consequence (e.g. change of therapy, further diagnostics -> e.g. other imaging consultation, intervention) Avoidance/avoidance of imaging/intervention	Quality Connection (1 very good 2 acceptable 3 unacceptable)	Speed Down+Upload (Mbit/s; Speedtest after supervision)	Realization By on-site examiners (1 very good 2 acceptable 3 inadequate)	Duration Super vision (min)
1							D U			
	Free text									
2							D U			
	Free text									
3							D U			
	Free text									
4							D U			
	Free text									

	Super visor	Examiner on site (if applicable>1)	Time Start	Name Patient	Diagnosis confirmation (Yes/No)	Consequence (e.g. change of therapy, further diagnostics -> e.g. other imaging consultation, intervention) Avoidance/avoidance of imaging/intervention	Quality Connection (1 very good 2 acceptable 3 unacceptable)	Speed Down+Upload (Mbit/s; Speedtest after supervision)	Realization By on-site examiners (1 very good 2 acceptable 3 inadequate)	Duration Super vision (min)
5							D U			
	Free text									
6							D U			
	Free text									
7							D U			
	Free text									
8							D U			
	Free text									

Question 1: I am.	
Supervisor	A01
Resident during intensive care rotation	A02
Resident during/after ultrasound rotation	A03
Pediatric specialist	A04
Senior/ Chief pediatric physician	A05
Resident before ultrasound rotation	A06
Questions 2: I went through ultrasound rotation at a pediatric hospital for at least 2 months.	
Yes	A01
No	A02
Question 3: I am familiar with the multi-level concept for education and training in ultrasound diagnostics of the German Ultrasound Society (DEGUM), section pediatrics.	
Yes	A01
No	A02
Not specified	A03
Question 4: I am certified at least with level 1 of the DEGUM pediatric certification.	
Yes	A01
No	A02
Not specified	A03
Question 5: I have attended at least one DEGUM ultrasound course.	
within the last 2 years	A01
within the last 3 to 5 years	A02
more than 5 years ago	A03
Never attended	A04
Question 6: I have been practicing ultrasound diagnosis on ultrasound phantoms since the beginning of my medical practice.	
Yes	A01
No	A02
Not specified	A03
Question 7: I independently perform pediatric sonography exams.	
Almost daily	A01
Several times a week	A02
Never actually	A03
Several times a year	A04
Several times a month	A05
Not specified	A06
Question 8: I feel confident enough to perform a sonographic examination in pediatrics independently.	
almost always	A01
no	A02
Rarely, frequently (> 50 % of cases) support desired	A03
Sometimes, sometimes (30-50 % of cases) support desired	A04
Frequently, occasionally (<20 % of cases) support desired	A05
Question 9: I am familiar with the technical applications of sonographic equipment in the pediatric clinic.	
is completely true	A01
rather does not apply, often I am uncertain	A02
Applies to the basic applications	A03
Applies to most applications	A04

Does not apply at all	A05
Question 10: In on-duty situations (evenings, nights, weekends), I would like to perform ultrasound diagnostics independently more often, but I postpone them or perform another diagnostic/consultation due to lack of time	
Very frequently (every duty shift)	A01
Frequently (every 2 nd to 3 rd duty shift)	A02
Sometimes (every 4 th to 5 th duty shift)	A03
Rarely (Less often than every 5 th duty shift)	A04
Never	A05
Question 11: In on-duty situations (evenings, nights, weekends), I would like to perform ultrasound diagnostics independently more often, but I postpone them or perform another diagnostic/consultation due to lack of ultrasound experience	
Very frequently (every duty shift)	A01
Frequently (every 2 nd to 3 rd duty shift)	A02
Sometimes (every 4 th to 5 th duty shift)	A03
Rarely (Less often than every 5 th duty shift)	A04
Never	A05
Not specified	A06
Question 12: In on-duty situations (evenings, nights, weekends), I would like to perform ultrasound diagnostics independently more often, but I postpone them or perform another diagnostic/consultation due to uncertainty and concern about overlooking a pathological finding	
Very frequently (every duty shift)	A01
Frequently (every 2 nd to 3 rd duty shift)	A02
Sometimes (every 4 th to 5 th duty shift)	A03
Rarely (Less often than every 5 th duty shift)	A04
Never	A05
Not specified	A06
Question 13: In on-duty situations (evenings, nights, weekends), I would like to have supervisory (in-person or online) support from a physician experienced in ultrasound diagnosis.	
Very frequently (every duty shift)	A01
Frequently (every 2 nd to 3 rd duty shift)	A02
Sometimes (every 4 th to 5 th duty shift)	A03
Rarely (Less often than every 5 th duty shift)	A04
Never	A05
Not specified	A06
Question 14: I participated in the supervision during the Live Stream project as a physician on site or was present in an accompanying capacity and found the support diagnostically in the clinical situation to be	
Very helpful	A01
Helpful	A02
Limited helpful	A03
Not helpful	A04
Not participated	A05
Not specified	A06
Question 15: I participated in the supervision during the Live Stream project as an on-site physician or was present in an accompanying capacity and found the support for my own education to be	
Very helpful	A01
Helpful	A02
Limited helpful	A03
Not helpful	A04
Not participated	A05
Not specified	A06
Question 16: During the Live Stream project, I refrained from supervision because I was worried/uncertain about the technical implementation	
yes, several times	A01

yes, sporadically	A02
No	A03
Not participated	A04
Not specified	A05
Question 17: During the Live Stream project I performed without supervision because I did NOT want to wake the supervisor up at night for an ultrasound examination, during daytime I would have called the supervisor.	
yes, several times	A01
yes, sporadically	A02
No	A03
Not participated	A04
Not specified	A05
Question 18: During the Live Stream project, I performed without supervision because I was concerned that I would not be able to meet the supervisor's hints/expectations adequately.	
yes, several times	A01
yes, sporadically	A02
No	A03
Not participated	A04
Not specified	A05
Question 19: During the Live Stream project, I performed without supervision because I was worried that supervision would take too long and I had many other duties ahead of me in this shift.	
yes, several times	A01
yes, sporadically	A02
No	A03
Not participated	A04
Not specified	A05
Question 20: I would support the continuation of the opportunity for supervision during duty hours at our pediatric hospital after project completion	
yes	A01
Yes and also during normal working hours	A02
Possibly	A03
No	A04
Not specified	A05
Question 21: I would welcome and perceive short, internal explanatory videos on the following topics on the intranet.	
Video 1: Selecting patient data and transducer	Y= Yes
Video 2: Selecting the right preset	Y= Yes
Video 3: Image optimization	Y= Yes
Video 4: Proper saving of images and videos	Y= Yes
Video 5: Application Doppler Sonography	Y= Yes
Video 6: Application Microvascular Imaging	Y= Yes
Video 7: Application Elastography	Y= Yes
Video 8. Sonographic procedure for the most important and most frequent medical questions in duty situations	Y= Yes

Supplement 5 Data Set Survey

Supplement 5 Data Set Survey

ID	Date	Q1	Q2	Q3	Q4	Q5
1	2023-01-09	1A001	AO01	AO01	AO01	AO04
2	2023-01-09	1A005	AO02	AO01	AO02	AO03
3	2023-01-09	1A004	AO01	AO01	AO02	AO01
4	2023-01-09	1A003	AO02	AO01	AO02	AO02
5	2023-01-09	1A001	AO01	AO01	AO01	AO01
6	2023-01-09	1A004	AO01	AO01	AO02	AO04
7	2023-01-09	1A004	AO01		AO02	AO04
8	2023-01-09	1A003	AO01	AO01	AO02	AO04
9	2023-01-09	1A003	AO01	AO01	AO02	AO04
10	2023-01-09	1A005	AO01	AO01		AO02
11	2023-01-09	1A004	AO02	AO01	AO02	AO04
12	2023-01-09	1A006	AO02	AO02	AO02	AO04
13	2023-01-09	1A006	AO02	AO01	AO02	AO04
14	2023-01-09	1A001	AO01	AO01	AO01	AO02
15	2023-01-09	1A003	AO02	AO01	AO02	AO04
16	2023-01-09	1A004	AO01	AO01	AO01	AO03
17	2023-01-09	1A003	AO01	AO01	AO02	AO04
18	2023-01-09	1A006	AO02	AO02	AO02	AO04
19	2023-01-09	2A005	AO02	AO01	AO01	AO03
20	2023-01-10	CA005	AO01	AO01	AO02	AO03
21	2023-01-10	1A006	AO02	AO02	AO02	AO03
22	2023-01-10	1A001	AO01	AO01	AO01	AO03
23	2023-01-10	1A001	AO02	AO01	AO01	AO04
24	2023-01-10	2A004	AO01	AO01	AO02	AO04
25	2023-01-11	CA005	AO01	AO02	AO02	AO03
26	2023-01-11	1A004	AO01	AO01	AO02	AO01
27	2023-01-11	1A004	AO02	AO01	AO02	AO03
28	2023-01-11	1A006	AO02	AO02	AO02	AO04
29	2023-01-11	1A004	AO02	AO02	AO02	AO04
30	2023-01-11	1A005	AO02	AO02	AO02	AO04
31	2023-01-13	CA004	AO02	AO01	AO02	AO04
32	2023-01-13	CA006	AO02	AO01	AO02	AO04
33	2023-01-13	CA005	AO01	AO01	AO02	AO04
34	2023-01-13	CA005	AO02	AO01	AO02	AO04
35	2023-01-13	CA006	AO02	AO01	AO02	AO02
36	2023-01-13	CA003	AO01	AO01	AO02	AO02
37	2023-01-13	CA004	AO02	AO02	AO02	AO03
38	2023-01-13	1A006	AO02	AO01	AO02	AO04
39	2023-01-13	1A006	AO02	AO01	AO02	AO04
40	2023-01-13	1A006	AO02	AO02	AO02	AO03
41	2023-01-13	1A005	AO01	AO01	AO01	AO03
42	2023-01-13	1A006	AO02	AO02	AO02	AO04
43	2023-01-13	1A005	AO01	AO01	AO02	AO04
44	2023-01-13	1A004	AO02	AO02	AO02	AO04
45	2023-01-13	1A005	AO02	AO01	AO02	AO04
46	2023-01-13	1A004	AO01	AO02	AO02	AO04
47	2023-01-13	1A004	AO01	AO01	AO02	AO04
48	2023-01-13	1A002	AO02	AO01	AO02	AO04
49	2023-01-17	1A004	AO01	AO01	AO02	AO04
50	2023-01-17	1A004	AO02		AO02	AO01
51	2023-01-17	1A005	AO01	AO01	AO01	AO03

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52	2023-01-17	1A005	AO02	AO01	AO01	AO04
53	2023-01-17	1A005	AO01	AO01	AO02	AO03
54	2023-01-17	1A005	AO01	AO02	AO02	AO04
55	2023-01-17	1A004	AO01	AO01	AO02	AO04
56	2023-01-17	1A004	AO01	AO01	AO02	AO03
57	2023-01-17	2A004	AO01	AO02	AO02	AO04
58	2023-01-17	2A005	AO02	AO01	AO02	AO03



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Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
AO02	AO01	AO01	AO01	AO04	AO05	AO05	AO04
AO01	AO02	AO05	AO04	AO04	AO04	AO04	AO04
AO02	AO05	AO05	AO04	AO05	AO04	AO04	AO02
	AO05	AO04	AO03	AO01	AO03	AO04	AO01
AO02	AO01	AO01	AO01	AO05	AO05	AO05	
AO02	AO01	AO05	AO04	AO02	AO03	AO04	AO03
AO02	AO05	AO04	AO04	AO03	AO04	AO04	AO02
AO02	AO04	AO04	AO03	AO02	AO04	AO03	AO02
AO02	AO05	AO04	AO04	AO02	AO04	AO04	AO02
AO01	AO01	AO01	AO04	AO04	AO04	AO04	AO04
AO01	AO05	AO04	AO04	AO02	AO04	AO04	AO02
AO02	AO03	AO02	AO05				
AO01	AO04	AO02	AO02	AO02	AO02	AO02	AO02
AO02	AO02	AO01	AO01	AO04	AO05	AO05	
AO01	AO04	AO05	AO03	AO02	AO03	AO03	AO02
AO02	AO05	AO04	AO04	AO03	AO05	AO05	AO02
AO02	AO04	AO05	AO04	AO02	AO03	AO03	AO01
AO02	AO03	AO02	AO02				AO02
AO02	AO03	AO02	AO05				
AO02	AO05	AO04	AO03	AO02	AO04	AO03	AO03
AO02	AO04	AO04	AO03	AO02	AO02	AO03	AO02
AO02	AO02	AO01	AO04		AO05	AO05	AO04
AO02	AO01	AO01	AO01	AO05	AO05	AO05	AO04
AO01	AO05	AO05	AO01	AO03	AO03	AO03	AO04
AO02	AO02	AO04	AO04				AO04
AO02	AO05	AO03	AO03	AO03	AO04	AO03	AO01
AO02	AO04	AO03	AO03	AO03	AO02	AO02	AO02
AO02	AO04	AO04	AO03	AO02	AO02	AO01	AO01
AO02	AO03	AO03	AO03	AO02	AO02	AO02	AO02
AO01	AO05	AO04	AO03	AO03	AO04	AO04	AO02
AO02	AO03	AO03	AO03	AO02	AO03	AO03	AO01
AO01	AO03	AO02	AO05	AO03	AO01	AO01	AO01
AO01	AO05	AO01	AO04	AO03	AO04	AO04	AO04
AO02	AO03	AO04	AO03	AO04	AO04	AO05	AO03
AO02	AO03	AO02	AO03				
AO02	AO04	AO03	AO03	AO02	AO03	AO01	AO01
AO02	AO04	AO02	AO03	AO01	AO02	AO02	AO01
AO02	AO03	AO03	AO02	AO01	AO01	AO01	AO01
AO02		AO02	AO05				
AO02	AO03	AO03	AO03		AO03	AO03	AO01
AO02	AO03	AO03	AO02				
AO02	AO02	AO05	AO03	AO03	AO04	AO03	AO03
AO02	AO03	AO02	AO03				AO01
AO02	AO04	AO04	AO03		AO02	AO02	AO02
AO02	AO03	AO02	AO05				
AO02	AO05	AO04	AO03	AO04	AO03	AO03	AO02
AO02	AO05	AO05	AO04	AO04	AO05	AO05	AO03
AO02	AO03	AO02	AO02	AO03	AO01	AO02	AO02
AO02	AO04	AO04	AO03	AO03	AO04	AO02	AO02
	AO05	AO05	AO03	AO02	AO05	AO05	AO04
	AO02	AO05	AO04	AO05	AO05	AO05	AO05

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AO02	AO05	AO05	AO02	AO03	AO04	AO04	AO04
AO01	AO02	AO05	AO04	AO03	AO03	AO05	AO02
AO02	AO03	AO03	AO05		AO01	AO01	AO01
AO02	AO02	AO05	AO04	AO04	AO04	AO04	AO02
AO02	AO04	AO04	AO02	AO03	AO03	AO04	AO02
AO02	AO02	AO04	AO03	AO02	AO03	AO04	AO03
AO02	AO02	AO04	AO03				AO03



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Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21 V1
AO01	AO01	AO03	AO03	AO03	AO03	AO02	
AO05						AO04	
AO01	AO01	AO03	AO03	AO03	AO03	AO03	
AO01	AO01	AO03	AO02	AO02	AO03	AO02	
AO01						AO03	
AO02	AO02	AO03	AO03	AO03		AO02	
AO01	AO02	AO03	AO03	AO03	AO03	AO03	
AO05	AO05		AO04	AO04	AO04	AO02	
AO01	AO01	AO03	AO03	AO03	AO03	AO02	Y
AO05	AO05	AO04	AO04	AO04	AO04	AO02	Y
AO05	AO05	AO03	AO02	AO03	AO03	AO02	
							Y
AO05	AO05	AO04	AO04	AO04	AO04	AO03	
						AO02	
AO05	AO05	AO04	AO04	AO04	AO04	AO03	
AO01	AO01	AO03	AO03	AO03	AO03	AO03	
AO02	AO02	AO03	AO04	AO04	AO03	AO03	
AO05	AO05	AO04	AO04	AO04	AO04	AO04	Y
AO05	AO05	AO04	AO04	AO04	AO04	AO03	Y
AO05	AO05	AO03	AO03	AO03	AO03	AO03	Y
AO01	AO01	AO03	AO02	AO03	AO03	AO02	
AO01	AO01	AO03	AO04			AO02	Y
		AO03					
AO01	AO01	AO03	AO03	AO03	AO03	AO03	
AO05	AO05	AO04				AO02	
AO01	AO01	AO03	AO02	AO03	AO03	AO02	
AO02	AO02	AO03	AO02	AO02	AO03	AO02	Y
AO05	AO05	AO04	AO04	AO04	AO04	AO02	
AO01	AO01	AO03	AO03	AO03	AO03	AO02	
AO05	AO05	AO04	AO04	AO04	AO04	AO02	Y
AO05	AO05	AO04	AO04	AO04	AO04	AO03	
AO05	AO05	AO04	AO04	AO04	AO04	AO02	Y
AO05	AO05	AO04	AO04	AO04	AO04	AO03	Y
AO05	AO05	AO04	AO04	AO04	AO04	AO02	Y
AO05	AO05	AO04	AO04	AO04	AO04	AO03	
AO05	AO05	AO04	AO04	AO04	AO04	AO02	Y
AO05	AO05	AO04	AO04	AO04	AO04	AO02	
AO05	AO05	AO04	AO04		AO04		Y
AO05	AO05	AO04	AO04	AO04	AO04	AO03	Y
AO05	AO05	AO04	AO04	AO04	AO04	AO02	Y
AO01	AO01	AO03	AO03	AO03	AO02	AO02	
AO05	AO05	AO03	AO03	AO03	AO03	AO02	Y
AO05	AO05	AO04	AO04	AO04	AO04	AO02	Y
AO05	AO05	AO03	AO03	AO03	AO03	AO03	
AO01	AO02	AO03	AO03	AO03	AO03	AO03	
AO05	AO05	AO04	AO04	AO04	AO04	AO03	
AO05	AO05	AO04	AO04	AO04	AO04	AO03	
AO01	AO01	AO03	AO03	AO03	AO02	AO02	
AO02	AO02	AO03	AO03	AO03	AO03		
AO01	AO05	AO04	AO04	AO04	AO04	AO02	Y

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AO05	AO05	AO04	AO04	AO04	AO04	AO02	Y
AO02		AO04		AO03	AO03	AO03	Y
AO05	AO05	AO04	AO04	AO04	AO04		Y
AO01	AO05	AO03	AO02	AO03	AO03	AO02	Y
AO01	AO01	AO03	AO03	AO03	AO02	AO03	
AO05	AO05	AO04	AO02	AO03	AO02	AO02	
AO05		AO04	AO03		AO04	AO02	



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Supplement 5 Data Set Survey

Y	Y	Y	Y	Y	Y	Y
Y	Y	Y		Y	Y	Y
Y	Y	Y	Y	Y	Y	Y
Y		Y	Y	Y	Y	Y
Y	Y		Y	Y	Y	Y
				Y	Y	Y



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Table 1: Pediatric Inpatient cohort

	Study period (12 weeks)	Documentation period (4 weeks)	Supervision period (8 weeks)
Patients	1247	432	815
Sex	54.4 % (n=678)	56.5 % (n=244)	53.3 % (n=434)
	45.6 % (n=569)	43.5 % (n=188)	46.7 % (n=381)
Age (years)	6.6 ± 6.0 (5; 0-34)	6.3 ± 5.8 (4; 0-18)	6.6 ± 6.1 (5; 0-34)
Duration (days)	6.4 ± 13.7 (3; 0-216)	6.4 ± 15.1 (3; 0-202)	6.3 ± 12.9 (3; 0-216)
Diagnosis	838	324	514
Oncology	22.8 % (n=191)	30.2 % (n=98)	18.1 % (n=93)
Pneumology	15.0 % (n=126)	16.0 % (n=52)	14.4 % (n=74)
Neurology	13.0 % (n=109)	14.2 % (n=46)	12.3 % (n=63)
Gastroenterology	11.5 % (n=96)	10.8 % (n=35)	11.9 % (n=61)
Neonatology	9.8 % (n=82)	7.4 % (n=24)	11.3 % (n=58)
Nephrology/ Urology	8.8 % (n=74)	8.0 % (n=26)	9.4 % (n=48)
Infectiology	5.3 % (n=44)	3.1 % (n=10)	6.6 % (n=34)
Cardiology	2.7 % (n=23)	2.5 % (n=8)	2.9 % (n=15)
Hematology	1.1 % (n=9)	1.5 % (n=5)	0.8 % (n=4)
Psychology	1.0 % (n=8)	0.6 % (n=2)	1.2 % (n=6)
Others (e.g. Orthopedics, Endocrinology)	9.1 % (n=76)	5.6 % (n=18)	11.3 % (n=58)

Table 2: Ultrasound examinations regarding cohorts and implementation

	Documentation period (4 weeks)	Supervision period (without supervision)	Supervision period (including supervision)
Ultrasound examinations	37	44	27
Sex	43.2 % (n=16) 56.8 % (n=21)	65.9 % (n=29) 34.1 % (n=15)	59.3 % (n=16) 40.7 % (n=11)
Age (years)	9.2 ± 5.6 (10.6; 0,1-17.4)	7.3 ± 5.5 (6.6; 0,1-18)	9.7 ± 6.2 (9.5; 0-17.9)
Duration (min)	9.9 ± 9.2 (7; 1-44)	7.1 ± 6.0 (5; 1-30)	14.4 ± 10.0 (13; 4-46)
Inpatients	56.8 % (n=21)	65.9 % (n=29)	77.8 % (n=21)
Outpatients	43.2 % (n=16)	34.1 % (n=15)	22.2 % (n=6)
days < 24 hours after presenting	3.2 ± 8.6 (0; 0-36) 87.1 % (n=30)	2,8 ± 8.1 (0; 0-46) 56.8 % (n=25)	4.8 ± 12.7 (0; 0-60) 70.4 % (n=19)
Working days	37.8 % (n=14)	34.1 % (n=15)	55.6 % (n=15)
Saturday/Sunday/Holiday	62.2 % (n=23)	65.9 % (n=29)	40.7 % (n=11)
Nighttime (0-6)	16.2 % (n=6)	31.8 % (n=14)	22.2 % (n=6)
Emergency	10.8 % (n=4)	2.3 % (n=1)	22.2 % (n=6)
Urgent	54.1 % (n=20)	79.5 % (n=35)	66.7 % (n=18)
Not urgent	35.1 % (n=13)	18.2 % (n=8)	11.1 % (n=3)
Without Ultrasound training	8.1 % (n=3)	13.6 % (n=6)	0 % (n=0)
Ultrasound training received	75.7 % (n=28)	59.1 % (n=26)	66.7 % (n=18)
Supervisor	16.2 % (n=6)	27.3 % (n=12)	33.3 % (n=9)
Supervision desired			
Yes	54.1 % (n=20)	N/A	N/A
Not	45.9 % (n=17)	N/A	N/A
Supervision helpful			
Clinical perspective			
Yes	N/A	N/A	100 % (n=27)
No	N/A	N/A	0 % (n=0)
Training perspective			
Yes	N/A	N/A	88.9 % (n=24)
No	N/A	N/A	11.1 % (n=3)

Table 3: Survey results regarding ultrasound examinations

Independent performance of US examinations	Percentage
Almost daily	8.6 % (n=5/58)
Several times a week (≥ 3 US exams/week)	17.2 % (n=10/58)
Never actually	25.9 % (n=15/58)
Several times a year (≥ 10 US exams/year)	20.7 % (n=12/58)
Several times a month (≥ 3 US exams/month)	25.9 % (n=15/58)
Not specified	1.7 % (n=1/58)
feel safe enough for pediatric ultrasound examination	
almost always	12.1 % (n=7/58)
no	19.0 % (n=11/58)
Rarely, frequently (> 50 % of cases) support desired	15.5 % (n=9/58)
Sometimes, sometimes (30-50 % of cases) support desired	31.0 % (n=18/58)
Frequently, occasionally (<20 % of cases) support desired	22.4 % (n=13/58)
Familiar with the technical applications of the US device	
is completely true	8.6 % (n=5/58)
rather does not apply, often I am uncertain	12.0 % (n=7/58)
Applies to the basic applications	41.4 % (n=24/58)
Applies to most applications	27.6 % (n=16/58)
Does not apply at all	10.3 % (n=6/58)
Postponement of US examination due to lack of time	
Very frequently (every duty shift)	5.2 % (n=3/58)
Frequently (every 2 nd to 3 rd duty shift)	25.9 % (n=15/58)
Sometimes (every 4 th to 5 th duty shift)	24.1 % (n=14/58)
Rarely (Less often than every 5 th duty shift)	13.8 % (n=8/58)
Never	6.9 % (n=4/58)
Not specified	24.1 % (n=14/58)
Postponement of US examination due to lack of US experience	
Very frequently (every duty shift)	6.9 % (n=4/58)
Frequently (every 2 nd to 3 rd duty shift)	12.1 % (n=7/58)
Sometimes (every 4 th to 5 th duty shift)	20.7 % (n=12/58)
Rarely (Less often than every 5 th duty shift)	27.6 % (n=16/58)
Never	15.5 % (n=9/58)
Not specified	17.2 % (n=10/58)
Postponement of US examination due to uncertainty and concern about overlooking a pathological finding	
Very frequently (every duty shift)	8.6 % (n=5/58)
Frequently (every 2 nd to 3 rd duty shift)	12.1 % (n=7/58)
Sometimes (every 4 th to 5 th duty shift)	19.0 % (n=11/58)
Rarely (Less often than every 5 th duty shift)	24.1 % (n=14/58)
Never	19.0 % (n=11/58)
Not specified	17.2 % (n=10/58)
Supervising support by ultrasound experienced physician desired	
Very frequently (every duty shift)	20.7 % (n=12/58)

Frequently (every 2 nd to 3 rd duty shift)	34.5 % (n=20/58)
Sometimes (every 4 th to 5 th duty shift)	12.1 % (n=7/58)
Rarely (Less often than every 5 th duty shift)	17.2 % (n=10/58)
Never	1.7 % (n=1/58)
Not specified	13.8 % (n=8/58)











