Dedicated pediatric neuro-oncology and body-oncology ExamCards

MRI in children is often challenging due to the variety in age groups and body sizes, as well as the extra effort required to ensure patient safety and comfort. Some challenges are related to the necessity of sedation for small children during scanning or possible examination-related anxiety and nervousness encountered in older children. An MR community of academics, clinicians, technologists and industry experts have been working together to build cooperative programs to standardize the imaging procedures and diagnosis workflow [1].

A dedicated set of pediatric ExamCards helps to not only establish routine workflow and generate consistent image quality, but also allows for increased focus on patient care during the entire procedure. Philips, in cooperation with a group of expert MRI users in Germany, is building an extensive set of dedicated ExamCards aimed at providing fast and clinically valuable examinations in pediatric neuro-oncology and body-oncology.

The approach for developing these dedicated pediatric protocols has been as follows:

1) Establish a pool of preliminary protocols based on clinical experience and guidelines from the European Society for Pediatric Oncology Brain Tumor Imaging Group (Nov 2017), considering the essential clinical needs and concerns.

2) Design a few candidate protocols based on consensus reached at the German Pediatric MRI User Meeting March 2019, taking into account typical clinical scenarios and technical conditions, such as scan time, image contrasts, motion compensation, etc.

3) Finalize the set of protocols based on feedback from patient examinations: radiologists providing qualitative assessment of the image quality and technologists commenting on scan operation. Image parameters are specifically adjusted according to patient age group, field strength, and coil selection.

This has resulted in four sets of pediatric MRI ExamCards for neuro-oncology and body-oncology, for 3.0T and 1.5T, see examples in the table below. The Neuro-Oncology ExamCards include protocols for 3D T1-weighted pre- and post-Gadolinium TFE, 2D T1-weighted TSE and FLAIR. The Body-Oncology ExamCards include T1w, T2w and STIR. DWI with ADC maps, without or with background suppression (DWIBS) is also included , which may be helpful to illustrate local surgical or ischemic injuries, and evaluate tumor status.

Latest techniques such as **MultiVane XD** [2], **3D Vane XD** [3], and **mDIXON XD** [4] are incorporated whenever useful to improve (motion) robustness in pediatric MRI. Powerful **Compressed SENSE** (C-SENSE) technology [5, 6] allows for a scan time reduction of approximately 30% using the same examination setup and is included in addition to the conventional scan protocols. Furthermore, SmartExam Brain is integrated for automatic planning with high reproducibility and consistency in follow-up studies of the same patient [7].

Examples of Philips pediatric ExamCards and sequences

PE = phase encoding; TR = repetition time; TE = echo time; TS = scan time;
B = neuroblastoma; MVXD = MultiVane XD; EC = ExamCard

Basic Neuro-Onco 3.0T ExamCards with 32-channel head coil

Neuro-Onco (Basic), 3T, 32-Cha Head Coil												conventional SENSE		C-SENSE	
Age group: 1 to 2 years	Mode / Plane	FOV [mm²]	Matrix	PE direction	Slice gap [mm]	Voxel [mm³]	TR [ms]	TE [ms]	FatSat	NSA	Halfscan	Accel. factor	TS [m:s]	Accel. factor	TS [m:s]
Survey / SmartBrain	2D / 3D	280 x 280	280 x 140	RL	10	1 x 2 x 10	15	5.1	-	1	-	-	0:18	- / 2	0:18/0:10
Sag 3D T1-TFE native	3D / Sag	230 x 230	230 x 230	AP	0	1 x 1 x 1	7.8	3.6	-	1	-	1.26 x 1.5	3:33	3	2:04
3D FLAIR aniso	3D / Tra	230 x 180	272 x 210	RL	0	0.85 x 0.85 x 3.3	4800	1650	SPIR	2	-	2.4 x 1.2	3:26	4	2:38
Sag 3D FLAIR (optioinal)	3D / Sag	230 x 230	192 x 192	AP	0	1.2 x 1.2 x 1.2	4800	1650	SPIR	2	-	2.5 x 2	3:55	6	3:20
DWI (b0, 500, 1000)	2D / Tra	230 x 230	152 x 106	AP	0.3	1.5 x 2.2 x 3	6533	88	SPIR	1	0.88	2	2:00	2	2:00
Cor T2-TSE	2D / Cor	230 x 180	354 x 260	RL	0.25	0.65 x 0.7 x 2.5	5962	80	-	1	-	1.2	3:00	1.9	1:54
T2-TSE	2D / Tra	230 x 180	354 x 260	RL	0.3	0.65 x 0.7 x 3	3875	80	-	1	-	n.a.	2:27	1.3	1:56
Gd Sag 3D T1-TFE	3D / Sag	230 x 230	230 x 230	AP	0	1 x 1 x 1	7.8	3.6	-	1	-	1.26 x 1.5	3:33	3	1:21
Gd 3D T1-TSE	3D / Tra	230 x 180	328 x 256	RL	0	0.7 x 0.7 x 3.3	500-600	30	SPIR	1 or 2	-	2.5 x 1.4	3:20	5	1:30-2:11
Total scan time													**25:30**		**17:10**
Age group: >2 years															
Survey / SmartBrain	2D / 3D	300 x 300	300 x 126	RL	10	1 x 1.95 x 10	15	5.1	-	1	-	-	0:18	- / 2	0:18 / 0:10
Sag 3D T1-TFE native	3D / Sag	240 x 240	284 x 284	AP	0	0.85 x 0.85 x 0.85	8.4	3.8	-	1	-	1.26 x 1.5	4:42	3.3	3:00
3D FLAIR aniso	3D / Tra	230 x 180	308 x 240	RL	0	0.75 x 0.75 x 3.3	4800	1650	SPIR	2	-	2.5 x 1.3	3:40	4.5	2:43
Sag 3D FLAIR (optional)	3D / Sag	250 x 250	224 x 223	AP	0	1.12 x 1.12 x 1.12	4800	1650	SPIR	2	-	2.5 x 2	5:31	7.5	3:50
DWI (b0, 500, 1000)	2D / Tra	230 x 230	152 x 106	AP	0.3	1.5 x 2.2 x 3	6478	87	SPIR	1	0.85	2	2:00	2	2:00
Cor T2-TSE	2D / Cor	230 x 180	420 x 270	RL	0.25	0.55 x 0.65 x 2.5	5962	80	-	1	-	1.2	3:11	1.9	2:15
T2-TSE	2D / Tra	230 x 180	420 x 270	RL	0.3	0.55 x 0.65 x 3	3963	80	-	1	-	n.a.	2:54	1.3	2:06
Gd Sag 3D T1-TFE	3D / Sag	240 x 240	284 x 284	AP	0	0.85 x 0.85 x 0.85	8.4	3.8	-	1	-	1.26 x 1.5	4:42	3.3	3:00
Gd 3D T1-TSE	3D / Tra	230 x 180	384 x 256	RL	0	0.6 x 0.7 x 3.3	500-600	30	SPIR	1 or 2	-	2.6 x 1.4	2:30-3:10	5-6.5	2:00
Total scan time													**30:00**		**21:10**

Body-Onco 1.5T ExamCards

Body-Onco (Basic + Gd + Neuroblastoma + Advanced), 1.5T, 32-Cha Torso + Posterior Coils												SENSE		Station [#] / Dynamic time [s]	EC Group
Age group: <6 years (3 mm)	Mode / Plane	FOV [mm²]	Matrix	PE direction	Slice gap [mm]	Voxel [mm³]	TR [ms]	TE [ms]	FatSat	NSA	Halfscan	Accel. factor	TS [m:s]		
Survey	2D / 3D	450 x 450	256 x 127	RL	10	1.76 x 3.54 x 15	7.7	4.6	-	1	-	n.a.	0:10		**Basic**
Cor STIR MVXD RTrig	2D / Cor	350 x 350	280 x 280	n.a.	0.3	1.25 x 1.25 x 3	2753	70	STIR	1	-	2.5	3:36		**Basic**
T1-FFE MVXD	2D / Tra	300 x 300	240 x 240	n.a.	0.3	1.25 x 1.25 x 3	257	4.6	-	1	-	2	3:03		**Basic**
T2 MVXD RTrig	2D / Tra	300 x 300	252 x 252	n.a.	0.3	1.2 x 1.2 x 3	2620	116	-	1	-	2	2:06	x2 stations	**Basic**
Sag STIR TSE Spine	2D / Sag	180 x 400	224 x 363	FH	0.3	0.8 x 1.1 x 3	2500	70	STIR	2	-	1.4	3:45		NB
Sag T1-TSE Spine	2D / Sag	180 x 400	256 x 452	FH	0.3	0.7 x 0.88 x 3	455	16	-	2	-	n.a.	3:13		NB
T2-TSE Spine	2D / Tra	130 x 130	188 x 140	RL	0.3	0.7 x 0.9 x 3	3214	110	-	2	-	n.a.	3:51		NB
Cor DWIBS (b100, 800)	2D / Cor	350 x 300	140 x 120	RL	0	2.5 x 2.5 x 3	2134	80	STIR	1	-	2.5	5:16		**Basic**
Cor 3D Angio	3D / Cor	350 x 300	388 x 270	RL	0	0.9 x 1.1 x 2.6	4.6	1.5	-	1	-	4	0:17 x3	dyn. 16.8 s	NB
Gd 3D T1-mDixon	3D / Tra	300 x 300	216 x 213	AP	0	1.4 x 1.4 x 3	5.8	1.8 / 4.0	Dixon	1	0.7 x 0.85	3	0:16	x2 stations	Basic Gd
Gd Cor 3D T1-mDixon	3D / Cor	350 x 350	252 x 252	RL	0	1.4 x 1.4 x 3	6.2	1.9 / 4.2	Dixon	1	0.8	3 x 1.5	0:17		Basic Gd
Gd Sag 3D T1-mDixon Spine	3D / Sag	180 x 400	180 x 400	FH	0	1.0 x 1.0 x 3	6.7	2.1 / 4.6	Dixon	4	0.7	1.5	3:32		NB
Gd 3D T1-TFE mDixon Spine	3D / Tra	100 x 100	124 x 124	RL	0	0.8 x 0.8 x 3	7	2.6 / 4.7	Dixon	6	-	1.8	2:36		NB
Total scan time													**35:30**		
3D T1-Vane mDixon RNav	3D / Tra	350 x 350	280 x 280	n.a.	0	1.25 x 1.25 x 3	5.7	1.9 / 3.3	Dixon	1	1 x 0.8	1 x 1.6	1:50		Advanced
DYN Vane mDixon	3D / Tra	350 x 350	176 x 176	n.a.	0	2.0 x 2.0 x 5	4.5	1.6 / 2.6	Dixon	1	1 x 0.8	1 x 2	0:35 x4	dyn. 35 s	Advanced
Gd 3D T1-Vane mDixon RNav	3D / Tra	350 x 350	280 x 280	n.a.	0	1.25 x 1.25 x 3	5.7	1.9 / 3.3	Dixon	1	1 x 0.8	1 x 1.6	1:50		Advanced
Age group: ≥6 years (4 mm)															
Survey	2D / 3D	500 x 500	284 x 142	RL	10	1.76 x 3.52 x 15	7.7	4.6	-	1	-	n.a.	0:13		**Basic**
Cor STIR MVXD RTrig	2D / Cor	430 x 430	320 x 320	n.a.	0.4	1.34 x 1.34 x 4	2449	70	STIR	1	-	2.5	4:12		**Basic**
T1-FFE MVXD	2D / Tra	400 x 400	296 x 296	n.a.	0.4	1.35 x 1.35 x 4	455	4.6	-	1	-	2	3:10	x2 stations	**Basic**
T2 MVXD RTrig	2D / Tra	400 x 400	308 x 308	n.a.	0.4	1.3 x 1.3 x 4	2262	110	-	1	-	2	2:30	x2 stations	**Basic**
Sag STIR TSE Spine	2D / Sag	180 x 330	224 x 290	FH	0.3	0.8 x 1.1 x 3	2668	70	STIR	2	-	1.4	3:39	x2 stations	NB
Sag T1-TSE Spine	2D / Sag	180 x 330	256 x 375	FH	0.3	0.7 x 0.88 x 3	522	16	-	2	-	n.a.	3:28	x2 stations	NB
T2-TSE Spine	2D / Tra	130 x 130	188 x 140	RL	0.3	0.7 x 0.9 x 3	3219	110	-	2	-	n.a.	3:52		NB
Cor DWIBS (b100, 800)	2D / Cor	420 x 420	140 x 140	RL	0	3 x 3 x 3	2087	76	STIR	1	-	3	4:19		**Basic**
Cor 3D Angio	3D / Cor	400 x 350	444 x 290	RL	0	0.9 x 1.2 x 2.6	4	1.3	-	1	-	4	0:17 x3	dyn. 16.8 s	NB
Gd 3D T1-mDixon	3D / Tra	400 x 300	288 x 234	AP	0	1.4 x 1.7 x 4	5.7	1.8 / 4.0	Dixon	1	0.7 x 0.85	3	0:16	x2 stations	Basic Gd
Gd Cor 3D T1-mDixon	3D / Cor	420 x 420	300 x 248	RL	0	1.4 x 1.7 x 4	6.1	1.9 / 4.1	Dixon	1	0.8	4 x 1.5	0:16		Basic Gd
Gd Sag 3D T1-mDixon Spine	3D / Sag	180 x 340	180 x 340	FH	0	1 x 1 x 3	6.6	2.1 / 4.6	Dixon	4	0.7	1.5	3:20	x2 stations	NB
Gd 3D T1-TFE mDixon Spine	3D / Tra	130 x 130	164 x 160	RL	0	0.8 x 0.8 x 3	6.5	2.2 / 4.3	Dixon	6	-	1.8	7:00		NB
Total scan time													**54:00**		
3D T1-Vane mDixon RNav	3D / Tra	350 x 350	260 x 260	n.a.	0	1.35 x 1.35 x 4	5.6	1.9 / 3.2	Dixon	1	1 x 0.8	1 x 1.6	1:50		Advanced
DYN Vane mDixon	3D / Tra	350 x 350	176 x 176	n.a.	0	2.0 x 2.0 x 5	4.5	1.6 / 2.6	Dixon	1	1 x 0.8	1 x 2	0:35 x4	dyn. 35 s	Advanced
Gd 3D T1-Vane mDixon RNav	3D / Tra	350 x 350	260 x 260	n.a.	0	1.35 x 1.35 x 4	5.6	1.9 / 3.2	Dixon	1	1 x 0.8	1 x 1.6	1:50		Advanced

This work is performed in collaboration with the following clinical institutes (in alphabetic order):

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7. To read more about SmartExam Brain, visit Philips MR Neuro Imaging at www.usa.philips.com/healthcare/resources/landing/neuro-mr