

Supplementary Methods 1: MRI-scanning protocols

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3T Philips Medical Systems (Best, the Netherlands) using a 32-channel head coil						
Sequence	Repetition time (TR) (ms)	Echo time (TE) (ms)	Flip angle (deg)	Acquired voxel size (mm)	Reconstructed voxel size (mm)	Other parameters
T1-weighted imaging volumetric 3D	9.5	4.6	8	0.78 x 0.91 x 1.20	0.78 x 0.78 x 1.20	
T2-weighted imaging coronal	4851	150	90	0.78 x 0.87 x 1.20	0.35 x 0.35 x 1.20	
Diffusion-weighted imaging axial	4912	101	90	1.18 x 1.30 x 3.00	0.80 x 0.80 x 3.00	b-value = 1000 s/mm ²
Susceptibility-weighted imaging axial	31	7.2	17	0.60 x 0.60 x 2.00	0.24 x 0.24 x 1.00	
Venography 3D	19	8.0	10	0.90 x 0.94 x 2.00	0.45 x 0.45 x 1.00	Phase contrast velocity 5-10 cm/s

3T GE Signa HDxt (Waukesha, USA) with a 8-channel head coil						
Sequence	Repetition time (TR) (ms)	Echo time (TE) (ms)	Flip angle (deg)	Acquired voxel size (mm)	Reconstructed voxel size (mm)	Other parameters
T1-weighted (BRAVO)	4.9	11.5	12	0.63 x 0.77 x 1	0.43x 0.39 x 0.5	
T2-weighted (fast relaxation fast spin echo sequence)	3976.0	110.0	111	0.40 x 0.48 x 2.5	0.35 x 0.28 x 2.5	
Diffusion-weighted imaging	3700.0	90.0	90	1.41 x 1.41 x 3	1.41 x 1.41 x 3	Diffusion directions = 35; b = 700 s/mm ²
Susceptibility-weighted imaging	58.0	38.0	20	0.39 x 0.94 x 3	0.39 x 0.29 x 3	

3T Philips Medical Systems (Best, the Netherlands) using a neonatal specific 32 channel head coil						
Sequence	Repetition time (TR) (ms)	Echo time (TE) (ms)	Flip angle (deg)	Acquired voxel size (mm)	Reconstructed voxel size (mm)	Other parameters
3D T1-weighted (magnetisation prepared rapid acquisition gradient echo)	11	4.6	9	0.81 x 0.8 x 0.8	0.76 x 0.76 x 0.8	TI:714ms
T2-weighted multislice turbo spin echo, sagittal and axial, with motion corrected reconstruction	12	156	90	0.81 x 0.82 x 1.6	0.8 x 0.8 x 0.8	
Diffusion-weighted imaging	3800	90	90	1.5 x 1.5 x 3, overlapping slices, gap -1.5 mm	1.5 x 1.5 x 1.5, overlapping slices, gap -1.5 mm	300 directions, b=0, 400, 1000, 2600 s/mm ²
Susceptibility-weighted imaging (spoiled gradient-recalled echo)	32	25	12	0.45 x 0.45 x 1.8		
Venogram	18	6.7	10	0.9 x 0.9 x 2		Phase contrast velocity 15 cm/s

Supplementary Methods 2: Scoring sheet perioperative brain MRI findings – European ABC Consortium*

ID				Age at scan (days of life)					
Date of Scan				Postmenstrual age (weeks)					
Preoperative				Postoperative					
Sequence	Y/N	Plane (<u>A</u> xial, <u>C</u> oronal, <u>S</u> agittal)		Slice thickness (mm)	Quality (<u>G</u> ood/ <u>A</u> verage/ <u>P</u> oor)				
T1									
T2									
DWI									
SWI									
Venogram									
LESION SCORE									
Haemorrhage	Yes / No								
	If yes, type:		IVH	Yes / No		Grade (I II III IV)			
			Subdural	Yes / No		Side (Infratentorial / Supratentorial / Both)			
	Comments								
White Matter Injury	Yes / No								
		Side (L/R/B)	Number	Size (2D)	Volume (3D)	T1 Signal	T2 Signal	DWI/ADC Signal	SWI Signal
	Frontal								
	Parietal								
	Temporal								
	Occipital								
	CST								
Comments									
Stroke	Yes / No								
		Side (L/R)	T1 Signal	T2 Signal	DWI/ADC Signal	SWI Signal			
	ACA								
	MCA main								
MCA anterior branch									

	MCA middle branch							
	MCA posterior branch							
	MCA cortical branch							
	Perforator branch							
	CST							
	Basal ganglia thalamus							
	Cortex							
	Comments							
Hypoxic-ischemic watershed injury	Yes / No							
	Side (L/R)	T1 Signal	T2 Signal	DWI/ADC Signal	SWI Signal			
Comments								
Cerebellar lesion	Yes / No							
		Side (L/R/B)	Number	Size (2D)	T1 Signal	T2 Signal	DWI/ADC Signal	SWI Signal
	Hemisphere							
	Vermis							
	Comments							
Sinovenous thrombosis	Yes / No							
		Side (L/R/B)	T1 Signal	Venogram				
	Superior							
	Transverse							
	Straight							
	Jugular							
Comments								
Other lesion	Yes / No							

ACA anterior cerebral artery; ADC apparent diffusion coefficient; B both; CST corticospinal tracts; DWI diffusion weighted imaging; IVH intraventricular hemorrhage; L left; MCA middle cerebral artery; PCA posterior cerebral artery; PLIC posterior limb of the internal capsule; R right; SWI susceptibility weighted imaging.

*Adapted from Beca J, Gunn JK, Coleman L, et al. *New White Matter Brain Injury After Infant Heart Surgery Is Associated With Diagnostic Group and the Use of Circulatory Arrest*. Circulation. 2013 Mar 5; 127(9):971-9.

Supplementary Table 1: Demographic and clinical characteristics

	N=202
Male, n (%)	131 (65)
Congenital heart disease, n (%)	
Transposition of the great arteries	114 (56)
Simple	80 (40)
Complex	34 (17)
Single ventricle physiology	41 (20)
Hypoplastic left heart syndrome	30 (15)
Hypoplastic right heart syndrome	9 (4)
Unbalanced atrioventricular septal defect	2 (1)
Left ventricular outflow tract obstruction	47 (23)
Coarctation	15 (7)
Hypoplasia with/without coarctation	19 (9)
Interruption	3 (2)
Aortic valve stenosis with coarctation/hypoplasia/interruption	5 (3)
Hypoplastic left heart complex	5 (3)
Antenatal diagnosis, n (%)	132 (65)
Cesarean section, n (%)	78 (39)
Inborn, n (%)	145 (72)
Birth weight	
Grams	3200 (2940-3648)
Z-score*	-0.16 (-0.77-0.48)
Gestational age, weeks	39.0 (38.3-40.0)
Twin, n (%)	7 (4)
Apgar score 5-minutes**	9 (8-9)
Head circumference at birth, cm	34 (33-35)
Balloon atrioseptostomy, n (%)	69 (34)

Transposition of the great arteries	65 (32)
Preoperative intubation, n (%)	111 (55)
Preoperative inotropes, n (%)	54 (27)
Age at surgery, days	10 (7-13)
Postmenstrual age at surgery, weeks	40.5 (39.7-41.7)
Cardiopulmonary bypass, n (%)	190 (95)
Postoperative mechanical ventilation, days	4 (2-6)
Intensive care stay, days	10 (7-17)
Hospital stay, days	27 (20-40)
30-day mortality after surgery, n (%)	4 (2)

Continuous data are presented as medians (25-75 percentiles) since most data were not normally distributed.

Categorical data are presented as number (percentages). *Z-score calculated with reference to the UK-WHO growth reference; **Missing ($\geq 5\%$): Apgar score 5-minutes (n=16), head circumference at birth (n=89).

Supplementary Table 2: Perioperative brain MRI findings

	Preoperative MRI	Postoperative MRI	Postoperative MRI
		New	Cumulative
	N=180	N=146	N=168
Age, days	6 (3-8)	22 (16-29)	22 (15-29)
Postmenstrual age, weeks	39.7 (38.9-40.9)	42.7 (41.2-43.7)	42.7 (41.2-43.8)
Time preoperative MRI-surgery, days	4 (2-7)	4 (2-7)	-
Time surgery to postoperative MRI, days	-	10 (7-15)	10 (7-15)
Time preoperative to postoperative MRI, days	-	14 (10-21)	-
White matter injury, n (%)	45 (25)	43 (30)	60 (36)
Single/multiple, n (%)	17/28 (38/62)	15/28 (35/65)	26/34 (43/57)
Single <2 mm, n (%)	3 (18)	2 (13)	4 (15)
Single 2-4 mm, n (%)	9 (53)	9 (60)	16 (62)
Single 4-6 mm, n (%)	2 (12)	3 (20)	4 (15)
Single >6 mm, n (%)	2 (12)	1 (7)	2 (8)
Lesion(s), No.	2 (1-5)	2 (1-5)	2 (1-5)
Largest lesion 2D, mm	3.6 (2.3-5.2)	3.5 (2.5-5.4)	3.5 (2.3-5.3)
Volume lesion(s) 3D, mm³*	40.5 (19-206.45)	61 (22-132)	49 (15-123)
Percentage of total brain volume**	0.01 (0.01-0.07)	0.02 (0.01-0.05)	0.01 (0.01-0.05)
Frontal, n (%)	24 (53)	32 (74)	41 (68)
Parietal, n (%)	33 (73)	28 (65)	42 (70)
Temporal, n (%)	7 (16)	4 (9)	8 (13)
Occipital, n (%)	9 (20)	7 (16)	10 (17)
Side left/right/both, n (%)	14/10/20 (32/23/46)	6/12/15 (18/36/46)	14/17/19 (28/34/38)
Corticospinal tracts involved, n (%)	7 (16)	8 (19)	9 (15)
DWI high signal/ADC low signal, n (%)	35 (78)	33 (77)	39 (65)
Arterial ischemic stroke, n (%)	11 (6)	15 (10)	24 (14)
Anterior cerebral artery	1 (9)***	0 (0)	1 (4)***

Middle cerebral artery	6 (55)***	4 (27)	8 (33)***
Main	1 (9)***	1 (7)	2 (8)***
Anterior branch	1 (9)	0 (0)	0 (0)
Middle branch	2 (18)	0 (0)	1 (4)
Posterior branch	1 (9)	0 (0)	1 (4)
Cortical branch	1 (9)	3 (20)	4 (17)
Perforator branch	4 (36)	11 (73)	15 (63)
Posterior cerebral artery	1 (9)	0 (0)	1 (4)
Side left/right/both	7/4/0 (64/36/0)	4/10/1 (27/67/7)	7/16/1 (29/67/4)
Corticospinal tracts involved	3 (27)	2 (13)	4 (17)
Basal ganglia thalamus involved	7 (64)	12 (80)	17 (71)
Cortex involved	5 (45)	4 (27)	9 (38)
DWI high signal/ADC low signal	10 (91)	12 (80)	14 (58)
Hypoxic-ischemic watershed injury, n (%)	3 (2)	1 (1)	2 (1)
Intraparenchymal cerebral hemorrhage, n (%)	0 (0)	6 (4)	8 (5)
Cerebellar hemorrhage, n (%)	10 (6)	3 (2)	10 (6)
Lesion(s), No.	2 (1-5)	1, 6, 6****	1 (1-6)
Largest lesion 2D, mm	3.1 (2.1-5.3)	1.0, 1.7, 6.4****	2.7 (1.7-6.9)
Intraventricular hemorrhage, n (%)	25 (14)	8 (6)	22 (13)
Germinal matrix or plexus (Grade I)	19 (76)	4 (50)	16 (72)
Inside ventricles (Grade II)	5 (20)	2 (25)	3 (14)
With enlarged ventricles (Grade III)	1 (4)	2 (25)	3 (14)
Periventricular hemorrhagic infarction (Grade IV)	0 (0)	0 (0)	0 (0)
Subdural hemorrhage, n (%)	53 (29)	25 (17)	49 (29)
Infratentorial	36 (68)	11 (44)	23 (47)
Supratentorial	6 (11)	6 (24)	9 (18)
Infra- and supratentorial	11 (21)	8 (32)	17 (35)

Cerebral sinovenous thrombosis, n (%)	0 (0)	15 (10)	17 (10)
Transverse	-	11 (73)	13 (77)
Straight	-	2 (13)	2 (12)
Transverse and jugular	-	2 (13)	2 (12)

Continuous data are presented as medians (25-75 percentiles) since most data were not normally distributed. Categorical data are presented as number (percentages). *Missing WMI-volumes due to motion corruption of 3D T1-images: n=7/45 preoperative MRI (16%), n=7/43 postoperative MRI new (16%), n=8/60 postoperative MRI cumulative (13%). **Missing relative WMI volume due to missing WMI volume segmentation or total brain volume segmentation due to motion corruption: n=15/45 cases with preoperative WMI (33%), n=12/43 cases with postoperative WMI new (28%), n=15/60 cases with postoperative WMI cumulative (25%). ***One patient had both an anterior and main middle cerebral artery stroke. ****Absolute values.

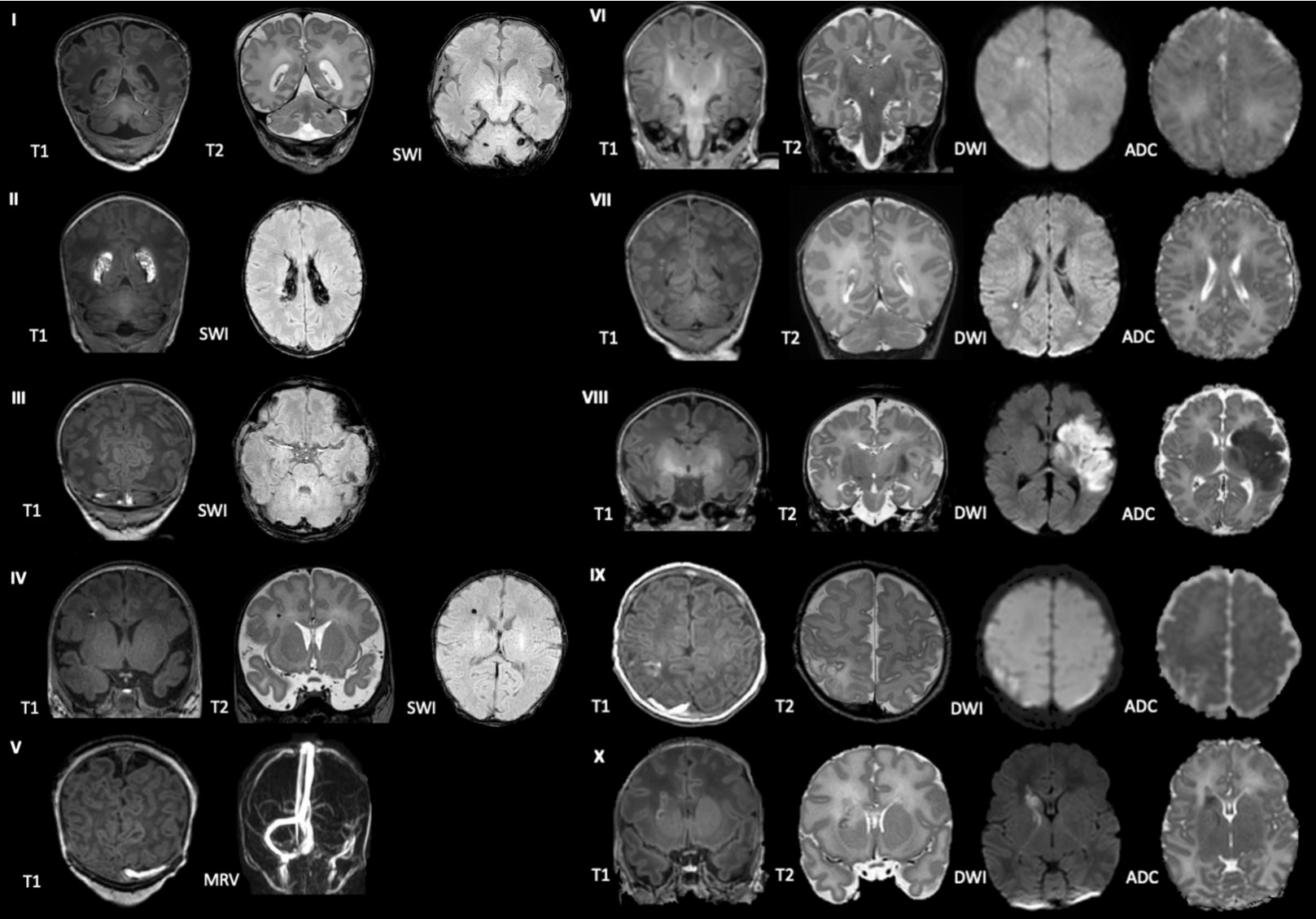
Supplementary Table 3: New postoperative brain lesions in infants with and without preoperative lesions

N=146	New postoperative lesions	New postoperative lesions
	<i>No</i>	<i>Yes</i>
Preoperative lesions	51	33
<i>No</i>	61%	39%
Preoperative lesions	32	30
<i>Yes</i>	52%	48%

In infants with both preoperative and postoperative MRI (n=146).

Subdural hemorrhages were not included in lesions.

Supplementary Figure 1: Examples of perioperative brain MRI findings in infants with severe congenital heart disease



Each number in the figure (I to X) represents an individual with an example of the neuroimaging findings observed in CHD perioperatively. I Cerebellar hemorrhage; II Intraventricular hemorrhage (grade III); III Subdural hemorrhage; IV Intraparenchymal cerebral hemorrhage; V Cerebral sinovenous thrombosis (transverse sinus); VI White matter injury (single large lesion); VII White matter injury (multiple punctate lesions); VIII Arterial ischemic stroke (main middle cerebral artery); IX Arterial ischemic stroke (small cortical middle cerebral artery) and subdural hemorrhage; X Arterial ischemic stroke (perforator).

ADC apparent diffusion coefficient image; DWI diffusion weighted image; MRV MR-venography; SWI susceptibility weighted image; T1/T2 weighted image