

Brain MRI findings in Pediatric Cerebral Malaria Predict Patient Outcome

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Purpose

We aim to characterize the patterns of signal abnormality and brain edema on low field magnetic resonance imaging (MRI) in children with cerebral malaria and determine its association with patient outcomes.

Methods

We evaluated children admitted to a pediatric hospital in Malawi over a period of six years who underwent brain MRI (0.35T Signa Ovation Excite MRI scanner) within 12 hours upon admission.

Two experienced neuroradiologists assessed the degree of edema [brain volume score (BVS)] and signal abnormality in the cortical and subcortical structures on T1-, T2-weighted and DWI sequences.

Cortical edema and signal abnormality patterns were categorized as (Figure 1):

- generalized edema without sparing
- occipital sparing
- peri-Rolandic sparing
- occipital and peri-Rolandic sparing

Additional area of edema and signal abnormality included basal ganglia (Figure 2), white matter (Figure 3), posterior fossa and splenium of the corpus callosum.

We compared imaging findings with patients' outcomes (dead, and alive with or without sequelae).

We used Chi-square and Fisher exact tests for univariate analysis. Linear and binary logistic regression analyses were applied to determine predictors of outcomes.

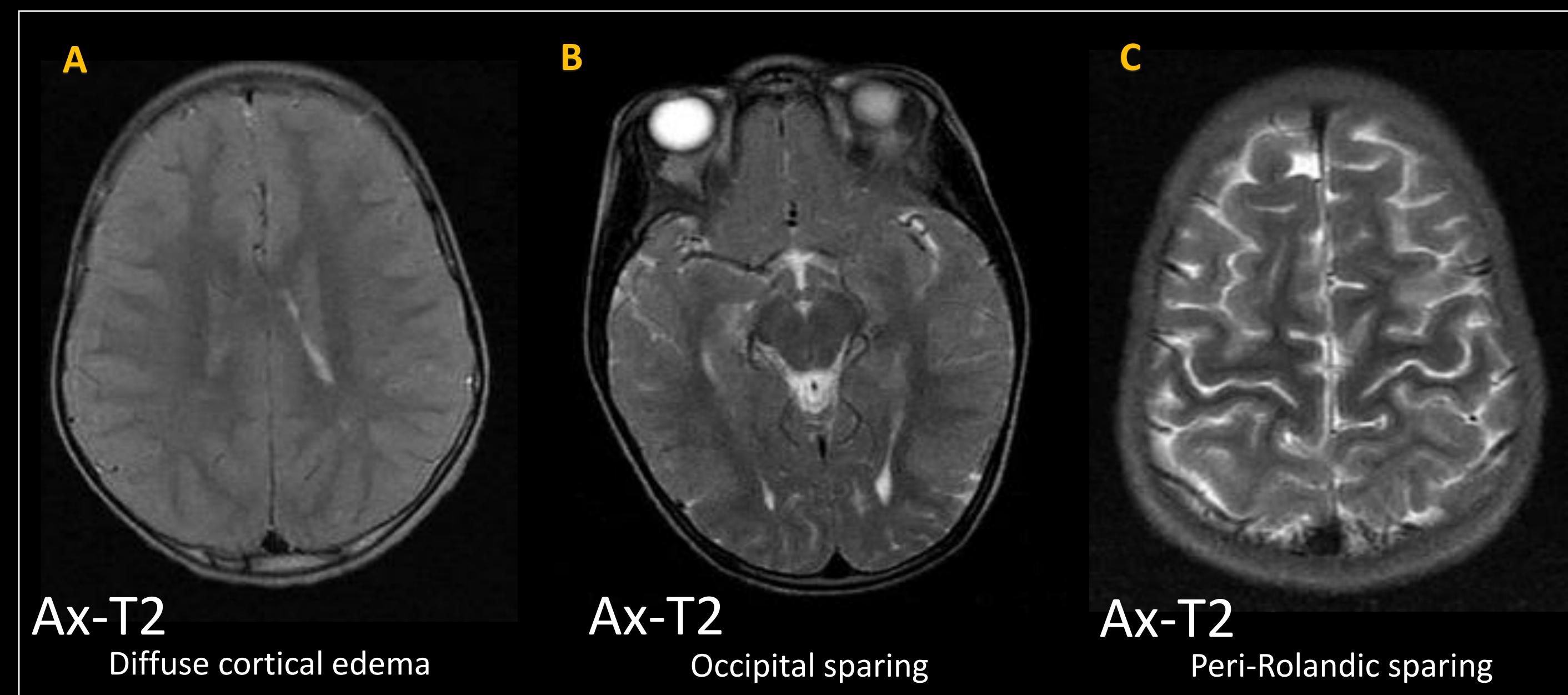
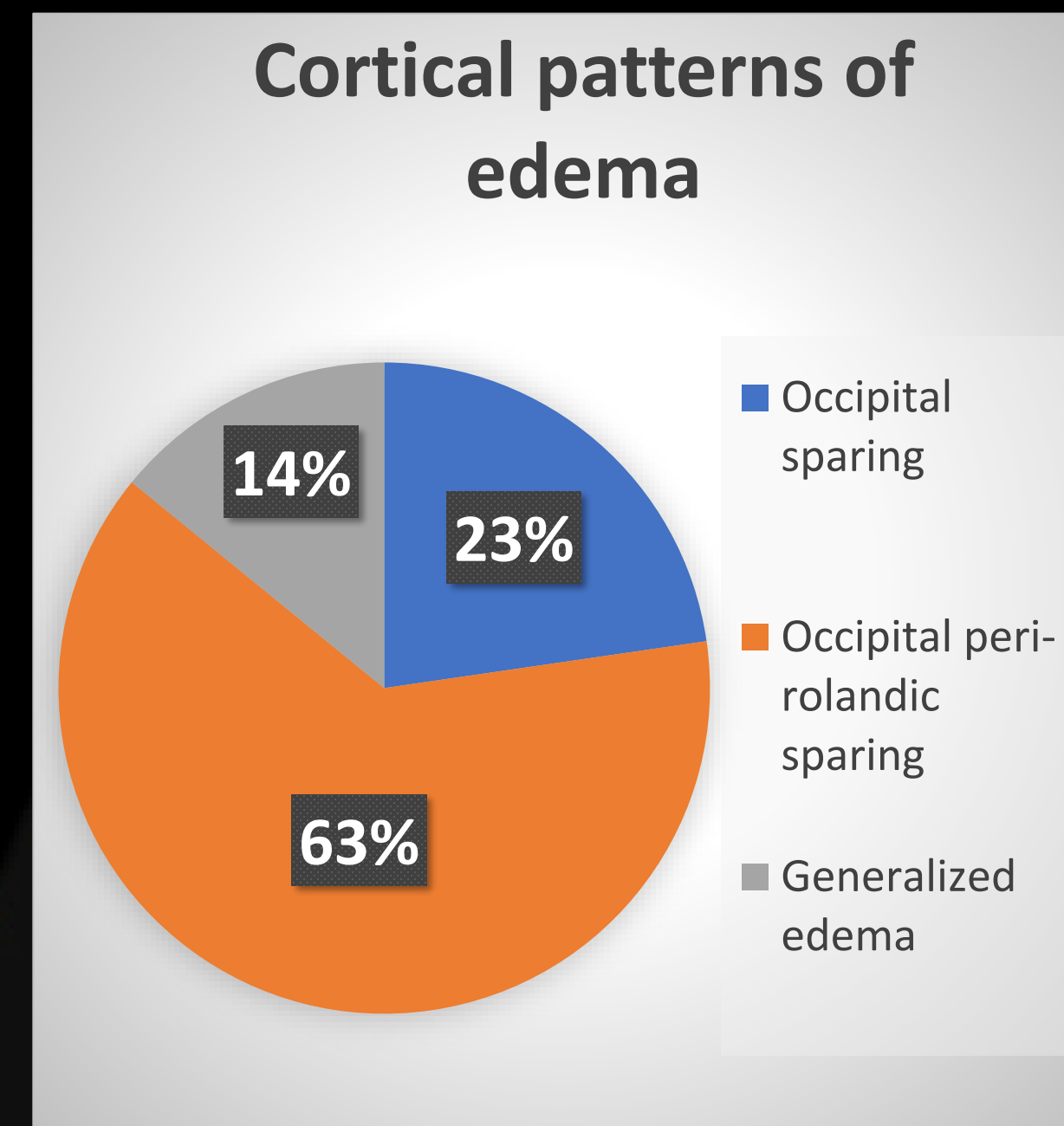


Figure 1: Axial T2W images (A) through the level of the corona radiata/centrum semi-ovale demonstrating diffuse cortical edema with increased signal in the cortex and subcortical region, (B) through the level of the midbrain demonstrating cortical edema with occipital lobe sparing, and (C) through the level of the central sulcus demonstrating cortical edema with peri-Rolandic region sparing.

Results

We described the brain cortical patterns of edema in 163 children [median age 50 months (IQR: 32 - 75)] with cerebral malaria using low field brain MRI.



Obvious edema was significantly associated with worse outcome (OR=6.5, $p < 0.001$).

After linear regression, patients with occipital-peri-Rolandic sparing had lower BVS ($\beta = -0.26$, $p < 0.001$) and better outcomes than those with general edema without sparing or occipital sparing pattern [OR (95% CI): 0.3 (0.1-0.6), $p = 0.002$] (Table 1).

Presumed predictors	B	95% CI	β	t	p value
Intercept	5.30	4.69, 5.92		17	<0.001*
BG T2	0.58	0.24, 0.93	0.24	3.36	0.001*
Age	0.001	- 0.004, 0.007	0.03	0.44	0.66
RD WM	0.32	- 0.11, 0.66	0.13	1.91	0.058
Atrophy	- 2.01	- 3.21, - 0.81	- 0.23	- 3.31	0.001*
Posterior fossa involvement	0.52	0.02, 1.03	0.145	2.04	0.04*
Occipital-peri-Rolandic sparing	- 0.64	- 0.98, - 0.29	- 0.26	- 3.61	<0.001*

BVS: brain volume score, CI: confidence interval, BG T2: basal ganglia involvement in T2 sequence, RD WM: restricted diffusion of the white matter
Mean \pm Standard deviation
* p value < 0.05
Note: for the linear regression model, R, R2 and adjusted R2 were 0.51, 0.26 and 0.23 respectively.

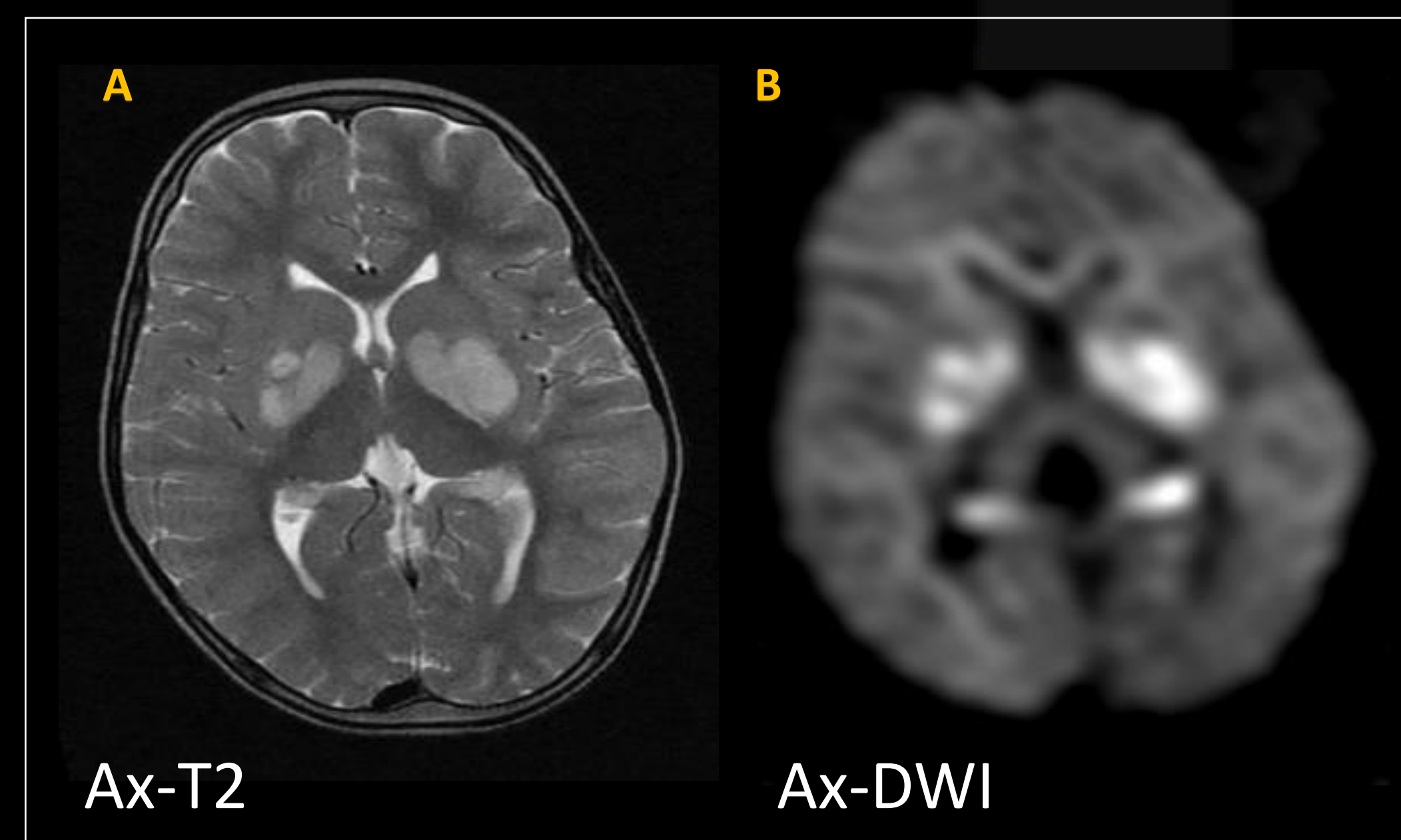


Figure 2: Axial T2W and DWI images through the basal ganglia demonstrating increased signal in bilateral lentiform nuclei and hippocampi.

Also, a higher BVS (adjusted OR=2.83, $p = 0.004$) were associated with increased mortality. Involvement of other structures were also associated with edema degree and outcomes (Table 2).

Presumed predictors	B	SE	Exp (B)	95% CI	p value
Infarct	2.44	1.38	11.47	0.76, 172.29	0.08
BVS	1.04	0.36	2.83	1.39, 5.73	0.004 *
Splenium involvement	- 3.27	1.50	0.04	0.002, 0.72	0.03 *
RD WM	- 1.21	0.6	0.3	0.09, 0.96	0.04 *
BG T2	1.43	0.61	4.2	1.35, 14.58	0.02 *
Occipital-peri-Rolandic sparing	- 0.67	0.59	0.51	0.16, 1.63	0.26
Age category (≤ 49 vs > 50 months)	-0.96	0.59	0.38	0.12, 1.21	0.1

B: logistic regression coefficient, SE: standard error, Exp (B): adjusted odds ratio, CI: confidence interval, BVS: brain volume score, RD WM: restricted diffusion of the white matter, BG T2: basal ganglia involvement in T2 sequence

* p value < 0.05

Note: for the binary logistic regression, R2 Nagelkerke= 0.52

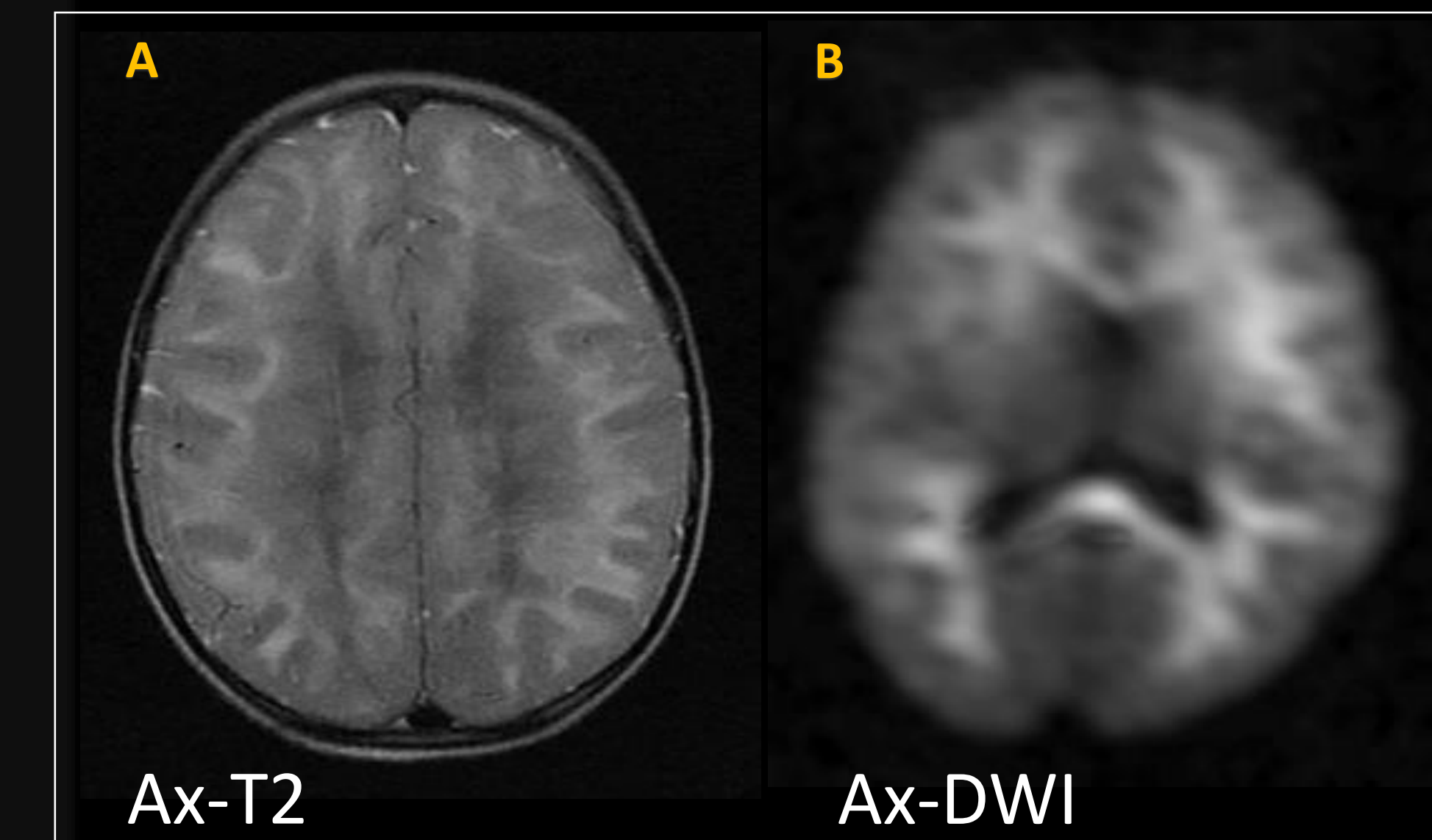


Figure 3: Axial images (A) through the centrum semi-ovale (T2W) and (B) lateral ventricles (DWI) demonstrating increased signal in the central and subcortical white matter, and central aspect of the splenium of the corpus callosum.

Conclusion

MRI findings in pediatric cerebral malaria are associated with brain edema and signal abnormality involving the cortex, white matter and deeper gray matter structures. Increased BVS is associated with worse outcomes. Most of our patients had occipital or occipital-peri-Rolandic cortex sparing. Interestingly, sparing of these areas was significantly associated with lower BVS and better outcomes in terms of mortality and/or sequelae. Furthermore, several findings could be used as predictors of BVS and/or mortality.

References:

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