

Cerebral Blood Flow, Autoregulation and Oxygenation in Pediatric Diabetic Ketoacidosis

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Background: Little is known about the pathogenesis of cerebral edema in pediatric diabetic Ketoacidosis (DKA). We examined cerebral blood flow (CBF), cerebral autoregulation, and cerebral oxygenation in 5 children with DKA and altered mental status (AMS). We tested the following hypotheses:

1. V_{mca} is decreased in children with DKA and cerebral edema,
2. Cerebral autoregulation is impaired in some children with DKA and this impairment results in cerebral edema,
3. Children with cerebral edema secondary to DKA have decreased mean brain oxygen saturations.

Methods: After IRB approval, subjects were enrolled if they met the following criteria: Age < 18 years, DKA and altered mental status, and a triad of pH < 7.25, serum glucose > 300 mg/dL and serum HCO_3^- < 15 meq/L. Transcranial Doppler ultrasonography, cerebral oximetry and computed tomography (CT) of the head were used to examine CBF and autoregulation, cerebral oxygenation and cerebral edema respectively.

Results: In 5 children with DKA and AMS,

1. V_{mca} was increased NOT decreased relative to MAP and CO_2 , at both 6 and 36 hours.
2. Cerebral autoregulation was impaired (4/5) early and normalized by 36 hours (Figure 1).
3. Hyperemia at 6 hours, but not at 36 hours, was associated with impaired cerebral autoregulation (Table 1).
4. Although cerebral saturations were increased in two patients early compared to 36 hrs, cerebral saturations did not predictably correlate with ARI or $V_{mca} CO_2$.
5. Compared to recovery at 36 hours, CT at 6 hours demonstrates measurable cerebral swelling.

Conclusions: In children with DKA and AMS,

1. Cerebral swelling may be related to hyperemia, and NOT ischemia.
2. Impaired autoregulation may be related to hyperemia.

Clinical Implications:

1. The practice of aggressive fluid replacement (during hyperemia + impaired cerebral autoregulation) in children with DKA and AMS may be undesirably associated with cerebral edema.

Pt (y)	pH pvCO ₂	MAPe	V_{mca}	ARI	pH pvCO ₂	MAPe	V_{mca}	ARI
1.6	7.25 22	59 → 49	63 → 55	0.25	7.37 32	110 → 93	67 → 67	1.0
11	7.23 23	70 → 55	70 → 61	0.40	7.36 35	68 → 41	97 → 102	1.0
15	7.01 16	65 → 50	106 → 90	0.31	7.34 34	81 → 61	73 → 73	1.0
16	7.24 25	62 → 50	48 → 38	0.0	7.33 40	80 → 52	45 → 55	1.0
17	6.91 13	72 → 52	126 → 95	0.11	7.26 24	84 → 55	56 → 56	1.0

Table 1: Autoregulation Results at 6 vs. 36 hours after PICU admission of 5 children with DKA and AMS. AMS = altered mental status, pH and PvCO₂ are venous blood gas samples, MAPe = mean arterial pressure at the external auditory meatus, mV_{mca} = mean middle cerebral artery flow velocity, mARI = mean autoregulatory index. $ARI \geq 0.4$ = intact cerebral autoregulation and $ARI < 0.4$ = impaired cerebral autoregulation, CT = computed tomography of the head. **V_{mca} is high relative to MAPe and CO_2 , ARI normalized by 36 hours.**

Figure 1: ARI at 6 vs. 36 hours. ARI = autoregulatory index; $ARI > 0.4$ = intact. 1/4 patients had intact autoregulation at 6 hours. ARI improved in all patients.

