Acute changes in ventricular volume during treatment for hepatic and renal failure

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Practical Implications

Evaluation of ventricular volume may suggest cerebral edema in patients with severe hepatic encephalopathy; renal replacement therapy may be associated with cerebral edema progression.

Hepatic encephalopathy (HE) exists on a spectrum from minimal dysfunction to coma and may arise from ammonia-associated neurotoxicity whereby metabolic dysfunction leads to glutamine accumulation, astrocyte swelling, and nitric oxide–induced vasodilation.¹ Elevated intracranial pressure (ICP), secondary to cerebral edema, is common in liver failure and occurs in 80% of comatose patients.^{1–3} Nonetheless, invasive ICP monitoring remains contentious in HE due to hemorrhagic complications and lack of evidence supporting benefit.³ A radiographic technique to assess edema could be helpful but head CT is only 33% sensitive for cerebral edema.^{2,3} We present a case illustrating this limitation of CT, the potential for rapid changes in cerebral edema, and a potential noninvasive means of assessing cerebral edema evolution.

Case report

A 52-year-old man with hepatitis C cirrhosis and mild chronic kidney disease was admitted with septic shock. Head CT obtained 3 weeks into the course of the current admission to evaluate slow cognitive improvement was reported to show generalized volume loss with mild increase in ventricular size compared to imaging obtained on admission. Neurologic consultation was requested for hydrocephalus.

Chart review revealed that the patient had been previously hospitalized at our institution nearly 2 months prior to the current admission with dyspnea and confusion, and a head CT at that time revealed diffuse volume loss (figure, A) but was otherwise unremarkable. He was treated for pneumonia and discharged with baseline mentation. One week later, he was readmitted with fever, hypotension, and altered mental status (the present episode). At readmission, he was intubated and demonstrated eye opening and symmetric withdrawal to pain (Glasgow Coma

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Figure Head CTs, total ventricular volumes, Glasgow Coma Scale scores, and serum laboratory results

Images show temporal horns, frontal horns, and bodies of the lateral ventricles; the patient's ventricular volume changes are most easily appreciated in these locations. Volumes decreased with worsening hepatic function, decreased further with rapid serum osmolality reduction (35 mOsm/L in 24 hours), and returned to near baseline as laboratory values normalized. (A) Prior hospitalization baseline: ventricle volume 67.3 mL, Glasgow Coma Scale (GCS) 15, sodium 132 mEq/L, blood urea nitrogen (BUN) 58 mg/dL, ammonia 50 μ mol/L. (B) Readmission with hepatic encephalopathy: ventricle volume 54.4 mL, GCS 7T, sodium 140 mEq/L, BUN 149 mg/dL, ammonia 197 μ mol/L, osmolality 342 mOsm/L. (C) After starting CVVH: ventricle volume 46.2 mL, GCS 4T, sodium 137 mEq/L, BUN 33 mg/dL, ammonia 52 μ mol/L, osmolality 295 mOsm/L. (D) At neurologic consultation: ventricle volume 75.0 mL, GCS 11T, sodium 141 mEq/L, BUN 21 mg/dL, ammonia 25 μ mol/L. Volumes determined using semiautomated computer software (Analyze Direct, Mayo Clinic, Rochester, MN).

Scale [GCS] 7T). Serum laboratory evaluation revealed ammonia 197 $\mu\text{mol/L}$, osmolality 342 mOsm, and blood urea nitrogen (BUN) 149 mg/dL. CT at readmission (figure, B) was reported to show mild volume loss, stable from prior hospitalization. The patient was treated with antibiotics, lactulose, and rifaximin; continuous veno-venous hemofiltration (CVVH) was initiated for acute-on-chronic renal failure. Twenty-four hours after readmission, hemodynamics had improved with sepsis therapy and serum evaluation showed ammonia 78 $\mu\text{mol/L}$, osmolality 307 mOsm, and BUN 66 mg/dL. Extensor posturing (GCS 5T) was noted. The next day there was no response to pain (GCS 4T), and another CT (figure, C) was reported as stable. Medical therapy continued with gradual clinical improvement over the ensuing 2 weeks.

By the time of neurologic consultation (figure, D), the patient was intubated but alert and following simple commands, with normal cranial nerve and motor examination (GCS 11T). He was diagnosed with resolved cerebral edema and resolving multifactorial encephalopathy, including HE. His cognition returned to baseline over the next few weeks.

DISCUSSION

Ventricular volumes have been shown to vary inversely with brain volumes in HE, even without apparent structural abnormalities, and volume changes after treatment for HE may reflect changing brain water content.⁴ Using semiautomated computer software (Analyze Direct, Mayo Clinic, Rochester, MN) known to accurately measure intracranial volumes,⁵ we demonstrate that our patient's ventricular volumes progressively decreased and then enlarged, corresponding to clinical deterioration followed by gradual improvement. These changes may represent evolving cerebral edema. Nevertheless, each isolated CT could be interpreted as showing no edema. One explanation for this discrepancy may be that cerebral atrophy in chronic liver disease limits the development of sulcal and cisternal effacement. Without these radiographic signs, edema may be overlooked on an isolated CT. Monitoring for ventricular volume changes over time may improve the sensitivity of CT for cerebral edema.

Our case also illustrates a potential complication of renal replacement therapy (RRT) in HE patients. Development of cerebral edema after acutely initiating RRT, including CVVH, is a recognized phenomenon and likely results from rapid fluid shifts causing a brain–blood osmolar gradient.^{6,7} Our patient had cerebral edema and marked hyperammonemia prior to CVVH, consistent with severe HE, but his neurologic deterioration and decrease in ventricular volume after rapid reduction in serum osmolality suggests that osmolar shifts may have exacerbated cerebral edema.

Our approach to severe HE patients requiring RRT begins with measuring serum osmolality. When elevated, we reduce the risk of provoking cerebral edema by decreasing serum osmolality slower than 10 mOsm/L every 12 hours, which may require hypertonic saline infusion. Although this approach has not been formally studied, our experience suggests reduced rates of further neurologic deterioration.

The presence of confounding factors, such as sepsis, that can contribute to encephalopathy is a limitation of our study. These confounders may complicate assessment of cerebral edema's contribution to the clinical picture. Our ventricular volume technique may be a means to gauge extent and progression of cerebral edema related to either HE or RRT but requires further investigation.

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