Driving Performance Among Patients with Cirrhosis Who Drove to Their Outpatient Hepatology Clinic Appointments

Paul J. Thuluvath [a], Anantha Nuthalapati [b], Jennifer Price [c], Anurag Maheshwari [a]

[a]University of Maryland School of Medicine & Mercy Medical Center, Medicine, 301 Saint Paul Place, Baltimore, MD 21202, United States, [b]Mercy Medical Center, Baltimore, MD 21202, United States and [c]Department of Medicine, University of San Francisco School of Medicine, San Francisco, CA, United States

Background: **Minimal hepatic encephalopathy (MHE) may adversely affect driving skills.** ***Aims:*** **To compare the driving performance of cirrhotic patients with and without prior HE as well as controls using a driving stimulator and to correlate psychometric testing with driving performance.** ***Methods:*** **Adult patients with cirrhosis, who drove to the outpatient clinic for their routine appointments underwent a battery of driving and psychometric tests including number connection tests A & B (NCT-A and NCT-B), digit symbol test (DST) and critical flicker and fusion frequency (CFF) testing.** ***Results:*** **Cirrhotics had significantly higher NCT-A (39.3 s vs. 31.2 s, $P = 0.006$) and DST scores (317 s vs. 245 s, $P = 0.012$), and lower CFF scores Fusion (33 vs. 36 Hz, $P = 0.05$), Flicker (35 vs. 42 Hz, $P = 0.007$) than controls. There was no difference in NCT-A, DST and CFF scores between patients with and without HE. Ten (22%) patients, 7 (27%) with prior HE and 3 (15%) without prior HE, had abnormal NCT-A scores (i.e. >control mean ± 2SD), and 12% of patients with prior HE had one or more driving test accidents, while controls and patients without prior HE had none. Patients with cirrhosis were more likely to hit pedestrians compared to controls ($P = 0.05$). There was no correlation between CFF, DST and NCTB scores with driving performance test results.** ***Conclusions:*** **Unlike previous reports, no significant differences were noted between the patients with and without prior HE on psychometric testing, and on the driving simulator, but driving accidents were seen in only those with previous history of HE. (J Clin Exp Hepatol 2016;6:3–9)**

Previous studies have shown that minimal hepatic encephalopathy (MHE) may adversely affect driving skills. MHE, a neurocognitive complication of cirrhosis characterized by impairments of attention, response inhibition, visual-motor coordination, and psychomotor speed in the absence clinical evidence of hepatic encephalopathy, is very common in patients with cirrhosis.[1–4] It has been suggested that the presence of MHE may predict future development of overt HE and may also impair daily functioning and health-related quality of life.[5–9] In another study, cognitive impairment (learning capacity and working memory) was found to be significantly impaired in patients with history of overt HE despite adequate therapy when compared to patients without prior overt HE. Moreover, there was cumulative worsening of cognitive function with recurrent episodes of overt HE.[10] Motor vehicle accidents are among the leading causes of morbidity and mortality in the United States, and it has been shown that patients with MHE have higher rates of traffic violations and motor vehicle accidents.[11–15] In one study, Schomerus et al. examined driving fitness in 40 patients with cirrhosis and found that 60% of patients may be unfit to drive on the basis of psychometric testing.[16] In another study, Wein et al. used a standardized 90-min on-road driving test and found that the fitness to drive a car was impaired in cirrhotic patients with MHE.[17] In contrast, a third study reported that patients with cirrhosis and portosystemic shunting did not exhibit a major impairment in their performance either on a driving simulator or during actual driving conditions when compared to matched controls.[18]

Despite some contrasting studies, there is increasing evidence to suggest that patients with MHE may have impaired driving skills resulting in higher automobile accidents when compared to those without MHE.[19,20] A decline in cognitive function including impaired visual orientation, attention span, reactivity, stress tolerance and speed of mental processing could perhaps explain the higher incidence of automobile accidents.[21,22] Anecdotally, the authors have seen many patients with significant cognitive impairment due to encephalopathy drive alone to their appointments at a hospital based in

Keywords: driving skills, cirrhosis, minimal hepatic encephalopathy, neuropsychometric testing
Received: 13.07.2015; *Accepted:* 18.09.2015; *Available online:* 3 October 2015
Address for correspondence: Paul J. Thuluvath, University of Maryland School of Medicine & Mercy Medical Center, Medicine, 301 Saint Paul Place, Baltimore, MD 21202, United States.
E-mail: thuluvath@gmail.com
Abbreviations: CFF: critical flicker and fusion frequency; DST: digit symbol test; HE: hepatic encephalopathy; MHE: minimal hepatic encephalopathy (MHE); NCT-A: number connection tests A; NCT-B: number connection tests B
http://dx.doi.org/10.1016/j.jceh.2015.09.003

Baltimore city. There are no current recommendations regarding routine assessment of driving abilities of patients with liver disease, nor is there consensus on the optimal testing modality to determine such patients' fitness to drive. Moreover, motor vehicle authorities provide no guidelines for driving tests or license renewal in patients with cirrhosis. In this study, our aims were to compare the driving performance of cirrhotic patients with and without prior HE as well as healthy controls using a driving stimulator task and to determine whether abnormal psychometric testing was associated with impaired driving performance.

METHODS

Adult outpatients (age >18 years) with cirrhosis who drove to the outpatient hepatology clinic for their routine appointments were asked to participate in the study. Patients were not informed about the study prior to their visits. Patients were excluded if they had untreated overt HE, or other neurological diseases that could potentially cause impaired cognition or impaired motor skills (e.g. Parkinson's disease). Patients with cirrhosis were excluded if they had consumed alcohol within 6 months. Healthy controls, who accompanied the patients, were excluded if they had consumed alcohol (socially) within 48 h before testing. Patients and controls were excluded if they were on benzodiazepines, antipsychotics and antiepileptic medications.

After obtaining written informed consent, all subjects answered a detailed sleep history questionnaire (sleeping time <6 h/night, sleep latency >30 min, awakenings (more than 3 episodes/night), daytime sleepiness (more than 4 episodes/week), daytime naps (more than 50 min/day), and then underwent a battery of psychometric testing including number connection tests A & B (NCT-A and NCT-B), digit symbol test (DST) and critical flicker and fusion frequency (CFF) testing. The control cohort consisted of family members of patients who accompanied the patients to their clinic visit. This study was conducted over a period of 6 months, and the study was approved by Institutional Review Board of the Mercy Medical Center and the Johns Hopkins Hospital.

NCT-A is a test of visuo-spatial orientation and psychomotor speed, and in addition to visuo-spatial orientation and psychomotor speed, NCT-B gauges the ability to shift attention. DST examines visuo-constructive abilities.[23] CFF is a computerized psychometric test that evaluates the maximum frequency, at which a flickering light source can still be perceived to flicker and measures a threshold for the fusion of these lights.[24] CFF threshold measures visual discrimination and general arousal, and has shown modest dependence on age and educational background.[25,26] For the purpose of this study, we considered control mean ± 2SD as abnormal for NCT-A (>46.3 s), NCT-B (>193.1 s), DST (>367), fusion (44.6) and flicker (55.5) testing.

The driving simulator task was performed on the same session immediately after the psychometric testing. The Beta Research Model 1100 driving simulator with STISim Drive simulation software (originally developed for the U.S. Department of Transportation) was used in this study. Details about the simulator set-up and software can be found in a prior publication of driving abilities in cirrhotic patients.[19] After a brief training to get acquainted with the simulator, all participants underwent the driving simulation task. The driving simulator test is comprised of two sections each lasting approximately 20 min each. The first section is called the driving and divided attention task and simulates driving in various terrains with differing road conditions and speed limits (e.g. city traffic, suburban roads, hilly terrain and highway speeds) while assessing the number of accidents and traffic violations. The second section is a navigational task in which patients are asked to travel from point A to B and back using a map. The road signs along the route are oriented to provide considerable assistance in following the designated route. Failure to follow the road signs and the designated route is assessed by the number of illegal turns that are recorded as errors during the task.

Wilcoxon rank sum test was used for statistical analysis of continuous variables and chi-square test for binary variables. The limit for statistical significance was set at $P \leq 0.05$. Stata 11.2 (StataCorp) was used for the analysis.

RESULTS

Forty-six patients with cirrhosis, 20 without and 26 with previous history of HE were compared to 17 healthy controls. The demographics of all groups are listed in Table 1. Compared to the cirrhotic group, controls were younger (mean age 44 years vs. 56.7 years, $P < 0.001$) and therefore had less driving experience (mean 22.7 years vs. 36.5 years, $P < 0.001$) were significantly lower in control group Chronic hepatitis C (50%) was the most common etiology of liver disease. The proportion of patients with alcoholic liver disease was similar among the two groups of patients with cirrhosis. Only two patients with cirrhosis had any alcohol within 6 months, and these two patients had non-alcoholic liver disease and had only an occasional drink within 6 months. None of the healthy controls had alcohol within 48 h before testing. None of our patients or controls was on benzodiazepines, antipsychotics, and antiepileptic medications. Patients with a history of HE had more severe liver disease than patients without prior HE as measured by MELD and CPT scores (Table 1). Complaints about sleep disturbance were significantly higher in individuals with prior HE (62%) compared to patients without prior HE (25%) and control group (6%). Educational background and driving citations in the last 3 years prior to the study were similar among all three groups. Among those with a prior driving citation, the majority of patients and controls had only 1 citation; one

