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Patterns of Hydrocephalus in Rural Haiti: A Computed Tomography–Based Study

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■ INTRODUCTION/OBJECTIVE: **Hydrocephalus is a common neurosurgical disorder that can lead to significant disability or death if not promptly identified and treated. Data on the burden of hydrocephalus in low-income countries are limited, given a lack of radiologic resources for the diagnosis of this condition. Here, we present an analysis of patterns of hydrocephalus from a large sample of computed tomography (CT) scans of the head performed at a public hospital in rural Haiti, a low-income country in the Caribbean.**

■ METHODS: **We analyzed reports from 3614 CT scans of the head performed between July 2013 and January 2016 for findings that were consistent with a diagnosis of hydrocephalus (report indicating "hydrocephalus," "ventriculomegaly," or "enlargement of the ventricles"). Extracted data included demographics, study indication, radiologic findings, and reported etiology of hydrocephalus.**

■ RESULTS: **In total, 119 scans had findings concerning for hydrocephalus (3.5% of all scans, 6.3% of abnormal scans; age range 0–90 years; median age 35.5 years; 49.6% male). Pediatric patients (<18 years of age) accounted for 39% of cases. In total, 113 of 119 (95%) scans had indications for possible neurosurgical intervention. Among these 113 scans, 36 (30%) scans demonstrated communicating hydrocephalus, 66 (55%) scans demonstrated noncommunicating hydrocephalus (primarily due to intraventricular hemorrhage [27 scans, 23%] or brain tumors [24, 20%]), and 11 (9%) scans were indeterminate regarding whether the hydrocephalus was communicating versus noncommunicating.**

■ CONCLUSIONS: **In a large sample of CTs performed in a rural low-income setting, hydrocephalus was common, predominantly noncommunicating, and often associated with potentially operable intracranial lesions. Data of this nature can inform research, policy, and clinical collaborations that strengthen the neurosurgical capacity of low-income countries.**

INTRODUCTION

Hydrocephalus is a common neurosurgical disorder that affects people of all ages.[1] Hydrocephalus can result from any condition that interferes with cerebrospinal fluid dynamics, including congenital brain malformations, trauma, infection, neoplasm, and intracranial hemorrhage.[2] If not promptly diagnosed and treated, hydrocephalus can lead to significant disability or death. Stagno et al.[1] cite a prevalence of hydrocephalus in high-income countries ranging from 0.9 to 1.2 per 1000 population; however, little is known about hydrocephalus in low-income countries (LICs), where access to radiologic diagnosis often is lacking or absent. Whereas high-income countries have an estimated 42 computed tomography (CT) scanners per 1 million population, LICs have only 0.32 scanners per 1 million population.[3] Even where CT is available in LICs, it often is inaccessible or unaffordable for most patients.[3] Data on the

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- Global surgery
- Haiti
- Hydrocephalus
- Neuroepidemiology

Abbreviations and Acronyms
CT: Computed tomography
ETV: Endoscopic third ventriculostomy
HUM: Hôpital Universitaire de Mirebalais
IVH: Intraventricular hemorrhage
LIC: Low-income country

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availability of magnetic resonance imaging scanners indicate that access to this technology is even more exclusive than for CT; for example, the regional density of magnetic resonance imaging scanners per 1 million population for the World Health Organization Africa region is 0.1, compared with a CT density of 0.4 per 1 million population for the same region.[4]

Limited data on pediatric hydrocephalus in LICs come from sub-Saharan Africa. With 36,000,000 births per year in sub-Saharan Africa, it is calculated that in this region, up to 180,000 new infant cases of hydrocephalus occur each year, and more than 100,000 newborns annually develop hydrocephalus before 1 year of age.[5,6] A disease-focused strategy of research and neurosurgical capacity building in Uganda has led to a deeper understanding of the burden of pediatric hydrocephalus in that country, where 60% of infant cases were reported to result from neonatal infection.[7] This work informed the development of innovative therapeutic approaches to address the disease burden in the Ugandan context, such as flexible endoscopic third ventriculostomy (ETV) with choroid plexus cauterization.[8]

Given evidence for effective strategies for the management of hydrocephalus in LICs, there is a need to better understand the burden and etiologies of hydrocephalus in this context for program and policy development. Here, we analyze radiologic patterns of hydrocephalus from a large sample of CT scans of the head performed at a public hospital in rural Haiti, an LIC in the Caribbean, examining causes of pediatric and adult hydrocephalus.

BACKGROUND

The Republic of Haiti occupies the western third of the Caribbean Island of Hispaniola. Its population is estimated to be 10.6 million as of July 2017, and its per capita GDP was estimated to remain unchanged at $1800 for the years 2015–2017.[9] With nearly 60% of the population living below the poverty line, Haiti is the, "poorest country in the Western Hemisphere." There are currently 4 neurosurgeons practicing in Haiti, all of who serve the population of the nation's urban capital, Port-au-Prince.[10] The current study was conducted at the Hôpital Universitaire de Mirebalais (HUM), a 205,000-square foot, 300-bed referral center in the rural city of Mirebalais in Haiti's Central Plateau.[11] HUM has a primary catchment of 185,000 patients and a tertiary catchment area of 3.4 million people from Mirebalais and surrounding regions.[11]

METHODS

Institutional Review Board Approval

Ethical approval for this study was obtained from the Institutional Review Boards of Zamni Lasante/Partners In Health, and Partners Healthcare.

Data Collection

CT studies of the head were obtained by local providers at HUM on a 32-slice helical CT scanner (BodyTom; Neurological/Samsung, Danvers, Massachusetts, USA), and stored locally on a picture archiving and communication system (Change Healthcare, Richmond, BC, Canada), mirrored in Boston, Massachusetts, USA. Studies were interpreted by 40 volunteer radiologists throughout North America. All radiologic reports were made available to clinicians in Haiti. Reports were deidentified, and data were analyzed using Microsoft Excel (Redmond, Washington, USA).

Data Analysis

The CT studies were performed between July 2013 and January 2016 at HUM, a public tertiary center in rural Haiti. Extracted data included demographics (age and sex of patient), referral source, study indication, and radiologic findings. CT reports were analyzed for findings consistent with hydrocephalus by evaluating radiology reports for the terms "hydrocephalus," "ventricular enlargement," trapped ventricles," "ventriculomegaly," and "enlargement of the ventricles." The reported etiology of hydrocephalus was determined from the radiologist's impression. Cases in which the radiologist proposed 2 or more possible etiologies without indicating which one was more likely were classified as ">1 possible etiology." Cases in which the radiologist could not differentiate between hydrocephalus and ex vacuo dilatation of the ventricles were classified as "atrophy present." In young children, although communicating hydrocephalus can be of either congenital or secondary etiology, no cases of communicating hydrocephalus in this data set were of exclusively congenital etiology. Among patients with noncommunicating hydrocephalus seen in this data set, the designation "congenital" was applied if: 1) the patient was <5 years and did not have an associated brain mass or intraventricular hemorrhage (IVH), or 2) if hydrocephalus was attributable to a congenital brain malformation, regardless of age.

RESULTS

During the study period, 3614 scans were performed on 3416 patients. Unless otherwise indicated, repeat scans were excluded from subsequent analyses. Of the 3416 initial scans, 119 (3.5%) had findings consistent with hydrocephalus. These 119 scans represented 6.3% of all initial scans with abnormal findings ($n = 1898$). Referrals for CT imaging of 88 (73.9%) of these patients originated from the emergency department, whereas the remaining patients came from the women's health ward (10 patients; 8.4%), the outpatient clinic (9 patients; 7.6%), the pediatrics ward (8 patients; 6.7%), the men's health ward (3 patients; 2.5%), and the neonatal intensive care unit (1 patient; 0.8%). The age of patients with hydrocephalus ranged from 0 to 90 years, with median age 35.5. **Table 1** shows the number of hydrocephalus cases observed in each age group. In total, 39% of cases occurred in pediatric patients (<18 years old) (**Table 1**); hydrocephalus was the second most common abnormal neurologic finding in pediatric patients after findings related to head trauma.

In 90% scans demonstrating hydrocephalus, the ordering clinician specified an indication for the head CT. **Table 2** shows the indications that led to discovery of hydrocephalus on imaging. Reported etiologies of hydrocephalus are shown in **Table 3**. Intracranial tumors were reported in 11 (55%) pediatric patients and 13 (29%) adults with noncommunicating hydrocephalus. IVH was reported in 24 adults older than 40 years old, accounting for 73% of noncommunicating hydrocephalus in that age group (see **Table 3** for detailed breakdown). Excluding 7 cases in this cohort for which the ordering clinician provided a history of trauma (**Table 2**), most cases of IVH and other intracranial hemorrhage in this series

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