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Brief Report

Retrospective study of cumulative diagnostic radiation exposure during childhood in patients with spina bifida

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Abstract

Background: The Biological Effects of Ionizing Radiation Committee of the National Academy of Sciences in 2005 and other expert panels have warned that risk of cancer increases with higher doses of radiation. Children with spina bifida and hydrocephalus have far greater exposure to radiation than the average person, starting almost directly after birth and continuing throughout their lifetimes.

Objective: The purpose of this study was to estimate the amount of ionizing radiation that patients with spina bifida and hydrocephalus are exposed to during childhood from diagnostic imaging.

Methods: Thirty patients, ages 18 years or older, with spina bifida and hydrocephalus were randomly selected from a spina bifida clinic and their radiology records were reviewed. Descriptive analyses were conducted. The total radiation exposure was then calculated for the study group, and the mean effective dose per patient was determined.

Results: In the study group, during their first 18 years, each patient had a mean of 55.1 studies and a median of 45 radiologic studies, a mean of 9.6 brain CT scans, and a mean cumulative effective dose of 81.9 mSv (2.6 mSv/patient/year over 18 years) and a median cumulative effective dose of 77.2 mSV of accumulated radiation exposure (4.5 mSv/patient/year over 18 years).

Conclusions: Clinicians should recognize that increased radiation exposure puts patients with spina bifida and hydrocephalus at higher risk for cancer. The population of children and adults with spina bifida and hydrocephalus should be surveyed for incidence of cancer.

Keywords: Spina bifida; Hydrocephalus; Childhood; Cancer; Cumulative effective radiation dose

Diagnostic imaging using ionizing radiation is a crucial tool in the management of patients with spina bifida, starting almost directly from the time they are born. During their childhood, a patient with spina bifida will have multiple CT scans of the brain to assess for associated Arnold-Chiari II malformation and hydrocephalus, and to evaluate the functioning of their ventriculoperitoneal shunt. They will also have an assessment of their neurogenic bladder with urodynamic studies and possible vesiculouretreral reflux via voiding cystourethrograms. Their skeleton will be X-rayed for orthopedic issues such as spinal curvature problems and hip sub-luxation. Hence, the patient with spina bifida will have a much greater exposure to radiation than the average person during their childhood.[1]

The generally increasing usage of radiologic imaging,[2,3] particularly CT scanning,[4] and its possible risks in children[5,6] and adults[7] have been a concern for some time. In response to concerns, radiologists have been trying to adjust their techniques[8] in order to use the safest and most appropriate doses of radiation when imaging children.[9–11] It has long been recognized that children are especially vulnerable due to increased sensitivity of growing tissues, possible long latency periods, and smaller cross-sectional areas exposed to radiation, than adults.[12] Studies examining the frequency[13] and risks of radiation exposure from computerized tomography in children have shown an increased incidence of cancer.[14–18]

Pearce et al published the first large-scale study in *Lancet* demonstrating evidence of increased risk of cancer in children from medical imaging; this study showed significant increases in leukemia incidence in children with cumulative bone marrow doses of at least 30 mSv, and significant brain tumor incidence in children with brain

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doses of at least 50 mSv.[16] Aalst et al found that the mean cumulative effective dose for a child with spinal dysraphism, was 23 mSv, with a range from 0.1 to 103 mSv.[19] Holmedal et al noted that the mean effective dose among children with spinal dysraphism that had CT scans was 3.2 mSV for children below 6 months of age, and 1.2 mSV for children above 6 months of age; the effective dose per CT scan differed by a factor of 64.[20] Brambilla et al conducted a systematic review indicating that the annual cumulative effective dose for patients with cerebrospinal fluid shunts and was less than 3 mSV per year.[21] There is limited data, however, about the total amount of ionizing radiation that children with spina bifida and hydrocephalus are exposed to during childhood. Thus, the purpose of this study was to estimate the amount of ionizing radiation that patients with spina bifida and hydrocephalus are exposed to in their first 18 years of life from diagnostic imaging.

Method

Design and setting

This was an observational retrospective cohort study examining the cumulative effective dose of radiation of children with spina bifida and hydrocephalus, starting in 2009. The spina bifida program is located within an urban, tertiary care children's hospital and is one of the largest centers in the world (with almost 500 patients).

Sample

There were 452 patients in the spina bifida clinic. Of these, 66 patients were over 18 years or above and 30 were randomly selected to retrospectively review their radiographic histories. Starting in 2009, patients were randomly selected to examine their radiation exposure periods during their first 18 years of life. Patient charts were randomly selected until the projected sample size was reached. Inclusion criteria were that patients were 18 years of age or above, had spina bifida (myelomeningocele) and hydrocephalus, and had been receiving their care at the spina bifida program since at least one year of age. Exclusion criteria were that they were less than 18 years of age, and had any other significant chronic illness not related to spina bifida and hydrocephalus (e.g. cystic fibrosis, cancer, congenital heart disease, chronic lung disease). To address potential sources of bias, we excluded chronic illnesses not related to spina bifida and hydrocephalus, such as cancer, as we wanted to quantify radiation dose only as it related to their spina bifida. Therefore, if they had any other radiation exposure, it wouldn't have been related to their spina bifida and hydrocephalus.

Data collection

The radiologic records of each of the 30 subjects were reviewed and the total number of imaging studies involving ionizing radiation (CT of the brain, voiding cystourethrogram, chest X-ray, abdominal X-ray, limb X-ray, spine X-ray, and CT of the abdomen/pelvis) were noted.

Measurement and outcomes

Using standard values[22] for the amount of radiation involved in each study, each recorded study was converted into a radiation dose, e.g. one CT of the head has a range of 2–4 milliSieverts (mSV). The milliSievert is the effective dose based on the radio-sensitivity of each exposed organ of radiation in partial irradiations. While some research studies examining more recent data may report the dose length product of each individual examination, the data collected in this study was from an 18-year period from 1991 to 2009; technology has changed over time and some of the records did not have information documented about effective dose and the number of studies. Thus, we used the standard values to calculate the effective dose per study per patient, which tends to be a more conservative estimate. The cumulative effective dose was then determined by adding up all of the individual doses over the 18-year period. The cumulative effective dose per patient was then averaged among the 30 subjects, determining the mean cumulative effective dose of ionizing radiation during childhood for a patient with spina bifida and hydrocephalus. The study was approved by the hospital Institutional Review Board.

Analysis

Descriptive analyses were conducted. The mean (standard deviation [SD]) and median (interquartile range [IR]) number of radiologic studies were calculated to estimate the number of studies that patients with spina bifida and hydrocephalus have in their first 18 years of life. The mean (SD) and median (IR) cumulative effective radiation dose per child over the first 18 years of life to estimate the amount of ionizing radiation that patients with spina bifida and hydrocephalus are exposed to in their first 18 years of life from diagnostic imaging.

Results

The majority of the patients, or over 80%, were of Hispanic descent. Of the patients who were excluded from the study, there were no patients with spina bifida and hydrocephalus who had cancer. Exposure to radiation was from the following diagnostic tests: CT scans of the brain, voiding cystourethrograms (VCUGs), chest X-ray, abdominal X-rays, spine X-rays, Limb X-rays, and CT scans of the abdomen or pelvis. In the study group, during their first 18 years, each patient had a mean of 55.1 (standard