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ORIGINAL ARTICLE

Trends in the utilization of computed tomography and cardiac catheterization among children with congenital heart disease



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Background/Purpose: Pediatric cardiac computed tomography (CT) is a noninvasive imaging modality used to clearly demonstrate the anatomical detail of congenital heart diseases. We investigated the impact of cardiac CT on the utilization of cardiac catheterization among children with congenital heart disease.

Methods: The study sample consisted of 2648 cardiac CT and 3814 cardiac catheterization from 1999 to 2009 for congenital heart diseases. Diagnoses were categorized into 11 disease groups. The numbers of examination, according to the different modalities, were compared using temporal trend analyses. The estimated effective radiation doses (mSv) of CT and catheterization were calculated and compared.

Results: The number of CT scans and interventional catheterizations had a slight annual increase of 1.2% and 2.7%, respectively, whereas that of diagnostic catheterization decreased by 6.2% per year. Disease groups fell into two categories according to utilization trend differences between CT and diagnostic catheterization. The increased use of CT reduces the need for diagnostic catheterization in patients with atrioventricular connection disorder, coronary

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arterial disorder, great vessel disorder, septal disorder, tetralogy of Fallot, and ventriculoarterial connection disorder. Clinicians choose either catheterization or CT, or both examinations, depending on clinical conditions, in patients with semilunar valvular disorder, heterotaxy, myocardial disorder, pericardial disorder, and pulmonary vein disorder. The radiation dose of CT was lower than that of diagnostic cardiac catheterization in all age groups.

Conclusion: The use of noninvasive CT in children with selected heart conditions might reduce the use of diagnostic cardiac catheterization. This may release time and facilities within the catheterization laboratory to meet the increasing demand for cardiac interventions.

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Introduction

Echocardiography and cardiac catheterization are common cardiac imaging modalities. Both modalities have drawbacks. The limitations of echocardiography include operator dependence, limited acoustic shadows, a small field of view, and poor evaluation of pulmonary veins. The limitations of cardiac catheterization include the overlapping of great vessels, difficulty in demonstrating systemic and pulmonary vessels at the same time, catheter-related complications, and high doses of iodinated contrast material and ionizing radiation. Computed tomography (CT) can overcome these limitations,¹ and previous studies widely reported its use in the evaluation of pediatric congenital heart disease.^{2–5}

However, there are long-term risks of developing lethal malignancy induced by radiation exposure of CT scan.^{6,7} Children are at higher risk than adults because their tissues are more radiosensitive and they have longer life expectancies to develop a radiation-induced malignancy.⁸

Recent studies have reported CT utilization trends in pediatric patients.^{9–11} Fahimi et al.⁹ reported a dramatic increase in CT utilization among children presenting to the emergency department with abdominal pain. Menoch et al.¹⁰ showed a decrease in CT utilization in recent years in the pediatric emergency department of a regional pediatric referral center. DeVries et al.¹¹ evaluated CT utilization patterns in children with recurrent headache and reported overuse of head CT despite existing guidelines. However, limited data are available to describe contemporary trends in the utilization of pediatric cardiac CT and catheterizations. The aim of this investigation is to study the impact of cardiac CT on the utilization of cardiac catheterization among children with congenital heart diseases in a tertiary referral general hospital.

Methods

Data collection

This retrospective study was conducted at a 2300-bed tertiary referral general hospital, which treated the majority of children with congenital heart disease in Taiwan. Informed consent was received for every case. The research protocol was approved by the local human research committee.

Consecutive patients who received pediatric cardiac CT, diagnostic catheterization, or interventional catheterization

from January 1999 to December 2009 were enrolled into the “CT group,” “cath-D group,” or “cath-I group,” respectively. Patients’ age, sex, and diagnosis from each CT and catheterization examination were identified. Patients aged >18 years were excluded from the study. Diagnoses were categorized into 11 groups based on the anatomical structures they primarily affect (Table 1). Some diagnoses from CT including lung agenesis, idiopathic pulmonary hypertension, infectious endocarditis, intracardiac tumor, and thrombi were excluded because these diagnoses were not considered congenital heart diseases.

Radiation dose

CT

We calculated the dose–length product (mGy cm) in each CT scan. The effective radiation doses were determined as the product of the dose–length products and the age-specific conversion factors. The age-specific conversion factors were 0.0766 mSv/(mGy cm) (newborn), 0.0442 mSv/(mGy cm) (1 year), 0.0291 mSv/(mGy cm) (5 years), 0.0217 mSv/(mGy cm) (10 years), and 0.0136 mSv/(mGy cm) (15 years) based on a previous report by Deak et al.¹² The age-specific effective radiation doses (mSv) of CT examinations were calculated accordingly.

Catheterization

We calculated the dose–area product (Gy cm²) in each catheterization. The effective radiation doses were determined as the product of the dose–area products and the age-specific conversion factors. The age-specific conversion factors were 3.7 mSv/(Gy cm²) (newborn), 1.9 mSv/(Gy cm²) (1 year), 1 mSv/(Gy cm²) (5 years), 0.6 mSv/(Gy cm²) (10 years), and 0.4 mSv/(Gy cm²) (15 years) based on the work of Karambatsakidou et al.¹³ The age-specific effective radiation doses (mSv) of catheterization were calculated accordingly.

Data analysis

Excel 2007 (Microsoft, Redmond, WA, USA) was used for data recording and presentation. Using general linear model on multivariate and repeated measures by SPSS (version 18; SPSS Inc., Chicago, IL, USA), trends between groups (CT vs. diagnostic catheterization) as well as annually within groups were analyzed. A *p* value of <0.05 was considered statistically significant.

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