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Radiation exposure from videofluoroscopic swallow studies in children with a type 1 laryngeal cleft and pharyngeal dysphagia: A retrospective review

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ABSTRACT

Introduction: Radiation exposure is recognized as having long term consequences, resulting in increased risks over the lifetime. Children, in particular, have a projected lifetime risk of cancer, which should be reduced if within our capacity. The objective of this study is to quantify the amount of ionizing radiation in care for children being treated for aspiration secondary to a type 1 laryngeal cleft. With this baseline data, strategies can be developed to create best practice pathways to maintain quality of care while minimizing radiation exposure.

Methods: Retrospective review of 78 children seen in a tertiary pediatric aerodigestive center over a 5 year period from 2008 to 2013 for management of a type 1 laryngeal cleft. The number of videofluoroscopic swallow studies (VFSS) per child was quantified, as was the mean effective dose of radiation exposure. The 78 children reviewed were of mean age 19.9 mo (range 4 mo–12 years). All children were evaluated at the aerodigestive center with clinical symptomatology and subsequent diagnosis of a type 1 laryngeal cleft. Aspiration was assessed via VFSS and exposure data collected. Imaging exams where dose parameters were not available were excluded.

Results: The mean number of VFSS each child received during the total course of treatment was 3.24 studies (range 1–10). The average effective radiation dose per pediatric VFSS was 0.16 mSv (range: 0.03 mSv–0.59 mSv) per study. Clinical significance was determined by comparison to a pediatric CXR. At our facility a CXR yields an effective radiation dose of 0.017 mSv. Therefore, a patient receives an equivalent total of 30.6 CXR over the course of management.

Conclusions: Radiation exposure has known detrimental effects particularly in pediatric patients. The total ionizing radiation from VFSS exams over the course of management of aspiration has heretofore not been reported in peer reviewed literature. With this study's data in mind, future developments are indicated to create innovative clinical pathways and limit radiation exposure.

1. Introduction

Exposure to ionizing radiation via medical imaging exams is recognized as having long term consequences, particularly in the pediatric population [1,2]. Children with swallow dysfunction may undergo several videofluoroscopic swallow studies (VFSS) over the course of management of aspiration.

Since the videofluoroscopic swallow study subjects patients to

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radiation, it is important to consider the risk/benefit tradeoff and attempt to minimize the amount of radiation exposure. The ALARA principal ("as low as reasonable achievable"), is the underlying fundamental principle for the safe use of radiological studies [1,2]. It is summarized by applying the concept of using the smallest amount of radiation to gain the necessary information. This principle not only applies to as low as possible exposure within each videofluoroscopic swallow study, but certainly would necessitate consideration on the total number of VFSS over the course of a diagnosis and management of swallow dysfunction in the setting of a pathology, for instance, an airway anomaly such as a type 1 laryngeal cleft.

A laryngeal cleft is a rare congenital anomalous connection between the larynx and esophagus. The most common classification system for laryngeal clefts used today was developed by Benjamin and Inglis (1989). Type 1 clefts are supraglottic interarytenoid clefts above the level of the true vocal folds. Type 2 clefts extend past the level of the true vocal folds, into the cricoid cartilage, but not through the cricoid cartilage. Type 3 clefts extend entirely through the cricoid cartilage into the cervical tracheoesophageal wall. Type 4 clefts extend through the majority of the tracheoesophageal wall [3].

Symptomatic laryngeal clefts present with choking episodes while feeding, aspiration, chronic cough, recurrent pulmonary infections, and/or failure to thrive [4]. Diagnosis is made by a multidisciplinary team including pediatric otolaryngologists, pulmonologists, gastroenterologists, and speech pathologists. Initial evaluation includes a thorough history and physical exam, office flexible laryngoscopy, and swallow exam [5–9]. Objective swallow exam can be implemented with a videofluoroscopic swallow study (VFSS), or functional endoscopic evaluation of swallowing (FEES) [10].

Pharyngeal dysphagia in children with anatomic laryngeal anomalies, in particular, a type 1 laryngeal cleft, can often be distinguished from children with neurological etiologies for dysphagia. Swallow dysfunction in children with a type 1 laryngeal cleft is frequently characterized by aspiration or penetration during the swallow with liquids. Solid food dysphagia is often not a predominant factor [11]. In contrast, the literature suggests that children with marked neurologic deficits as the primary etiology of their aspiration (e.g. cerebral palsy, Down syndrome) may present with oropharyngeal dysfunction with both liquids and solids [28]. Dysphagia may be characterized by impaired oral motor control resulting in premature propulsion of the bolus and aspiration prior to the swallow. A weak or uncoordinated pharyngeal stripping wave in this neurological population can also result in inefficient clearing of the bolus from the pharynx, resulting in aspiration of post-swallow residue [12,13]. Our institution's focus on patients with a type 1 laryngeal cleft with swallow dysfunction allowed for specific investigation and analysis based frequently on pharyngeal dysphagia patterns of aspiration or penetration during the swallow with liquids.

The gold standard for definitive diagnosis of a laryngeal cleft has been described as microlaryngoscopy with palpation of the interarytenoid space [9]. At our institution we prefer suspension laryngoscopy with implementation of either infant or pediatric vocal fold distractors. This facilitates inspection and palpation of the interarytenoid space. Chien et al. developed a functional algorithm for diagnosis and management of type 1 laryngeal clefts addressing when to proceed to surgical intervention from conservative management [6]. The algorithm was later updated by Ojha, which included postoperative management [7].

Currently, there is variation in the literature regarding postoperative management strategies [4,10,14–16]. A swallow evaluation is an integral component to postoperative assessment. At our institution, we perform a postoperative VFSS and/or clinical examination as detailed by Ojha's algorithm. Execution of this exam, particularly in pediatrics, challenges the clinician to balance obtaining adequate objective data to establish a safe diet, while limiting radiation exposure. While performing a fiberoptic endoscopic evaluation of swallowing (FEES) on some children may be a consideration, given the age group of this population (mean of 19.9 months) the FEES exam may not be a viable option for accurate results given significant compliance and participation limitations in the toddler years [7].

While reducing radiation in children is well documented, there is only a small body of research to date which focuses on pediatric exposure from pediatric VFSS [19], and there are no publications to date which examine the total number of VFSS exams a patient may undergo over the course of management of any one medical diagnosis. The literature contains information regarding radiation exposure during adult VFSS exams [20–22], however there are no reported studies which have evaluated radiation dose using continuous fluoroscopy with pediatric patients. While the use of pulse fluoroscopy to capture aspiration or penetration continues to be debated in the literature [23,24], our institution employs continuous fluoroscopy for all VFSS exams. Weir (2007) [19] studied a population of pediatrics, however their imaging techniques included the use of pulse fluoroscopy. Chau (2009) included a subset of their patient population to assess pediatric effective doses (N = 31 pediatric patients of their total sample size of 398 cases), however it is not stated if this was via use of pulse fluoroscopy or continuous fluoroscopy [22]. Furthermore, there was no reference to organ tissue dosing based on age.

The goal of this study was to quantify the total radiation exposure from the VFSS medical imaging exam, throughout the management of a type 1 laryngeal cleft repair. To achieve this, we determined the radiation dose per study at our institution and applied it to retrospective data on the number of VFSS exams each patient received over the management course of a type 1 laryngeal cleft.

2. Methods

We performed a retrospective review of 78 children seen in a tertiary pediatric aerodigestive center for management of a type 1 laryngeal cleft from September 2008 to 2013. Our two clinical objectives were 1) to calculate the number of VFSS exams patients receive over the course of the management of a type 1 laryngeal cleft, and 2) to determine the amount of ionizing radiation children exposed to per VFSS and highlight the clinical significance of this exposure.

2.1. Videofluoroscopic procedures

Barium Administration: Standard administration of Barium volumes and viscosities frequently constitute adult studies. Pediatric studies, alternatively, require an individualized approach due to the nature and challenge of participation and compliance in this young age group, often presenting the most critical viscosity and volume first. For this population of children with a suspected laryngeal cleft, liquids only of varying viscosities are typically examined under fluoroscopy. Preformulated Barium viscosities (thin, nectar, honey, and if indicated pudding) from Varibar E-Z-EM, (Lake Success, NY) may be presented. In addition, institution developed standardized modifications are offered (ultra-thin, half-strength nectar and half-strength honey thick barium). Liquids are presented from the child's typical drinking device (i.e., bottle, sip cup, straw cup, syringe, open cup).

Positioning equipment: The patients are seated in a tumbleform