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Velopharyngeal videofluoroscopy: Providing useful clinical information in the era of reduced dose radiation and safety

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ABSTRACT

Background: The state of the art for correcting velopharyngeal insufficiency (VPI) is a surgical procedure which is customized according to findings on imaging procedures: multiplanar videofluoroscopy (MPVF) and flexible videonasopharyngoscopy (FVNP). Recently, the use of MPVF has been challenged because of the potential risk of using ionizing radiation, especially in children.
Objective: To study whether using a protocol for performing MPVF can effectively decrease radiation dose in patients with VPI while providing useful information for planning surgical correction of VPI in combination with FVNP. The methodology used for performing the imaging procedures is described as well as the effectiveness of the surgical procedure.
Material and methods: Eighty - nine patients (Age range = 3–17 years; median = 5.5 years) with VPI resulting from multiple etiologies were studied. All patients underwent MPVF and FVNP for planning surgical correction of VPI. Radiation dosage data in each case was recorded. Forty of the 89 patients also completed a postoperative evaluation. Eleven out of the remaining 49 patients have not completed a postoperative evaluation and 38 patients are still pending surgical correction.
Results: Radiation dosage ranged from 1.00 to 8.75 miliSieverts (mSv); Mean = 2.88 mSv; SD = 1.575 mSv. Preoperative nasometry demonstrated mean nasalance ranging from 41%–95%; Mean = 72.30; SD = 4.54. Postoperatively mean nasalance was within normal limits in 36 (90%) out of 40 cases, ranging from 21% to 35%; Mean = 28.10; SD = 5.40. Nasal emission was eliminated postoperatively in all cases.
Conclusion: MPVF provides useful information for planning the surgical procedure aimed at correcting VPI. The combination of MPVF and FVNP is a reliable procedure for assessing velopharyngeal closure and to surgically correcting VPI with a highly successful outcome.

1. Introduction

Combining flexible videonasopharyngoscopy (FVNP) and multiplanar videofluoroscopy (MPVF) has been reported as the best approach for assessing velopharyngeal sphincter (VPS) function during speech [1–4]. FVNP provides dynamic direct visualization and in – vivo imaging of the vocal tract during articulation whereas MPVF uses ionizing radiation during fluoroscopy to show the movements of the structures of the VPS from different imaging planes.

In recent years, the use of MPVF for assessing the VPS has become somewhat controversial because the medical literature has suggested theoretical risks of excess cancers including fatal cancers from ionizing radiation especially in young children (who constitute the population in which MPVF is more frequently used as a diagnostic tool). Yet MPVF remains an integral component in the assessment and treatment planning of patients with VPI. The earliest recorded examination of the VPS in motion during speech was reported by Hilton in 1836 [5,6]. Williams published his book about Roentgen rays in medicine and surgery in 1901 [6]. He described the use of X – rays as an aid in diagnosis and also as a

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therapeutic agent. The earliest radiographic assessment of the velopharyngeal valve appeared in 1909 [7].

It is interesting that the same period of time saw the introduction of another invisible phenomenon "greatly feared as a deadly threat to health": electricity. However, at the present time there is no equivalent social acceptance of radiation as compared to electricity.

At the present time, medical sources of radiation affecting the population are increasing. This is of particular concern in children whose tissues are more radiosensitive, whose organs receive a larger effective dose for a given level of ionizing radiation, and who have an increased time to potentially develop cancers as a result of radiation exposure. Moreover, it has been suggested that the risk is cumulative with repeated radiation exposure [8]. Therefore all studies that expose a child to ionizing radiation should be carefully evaluated as to the potential risk versus the likely benefit. When an imaging procedure is being considered for use as a diagnostic marker, it is necessary to determine if the exam is actually needed and if no other study can provide the same information without ionizing radiation. MPVF can provide actual size measurement of the structures and movements of the VPS during speech. It also provides dynamic visualization of the entire area of both lateral pharyngeal walls. Finally, it gives one information about the depth of velopharyngeal closure during speech, enhancing a 3 - D analysis of the VPS. None of these data can be provided by any other diagnostic procedure including VNP.

When a MPVF is performed, it should be considered that the amount of radiation resulting from these fluoroscopic procedures is highly variable, depending upon the individual radiologist's skill and fluoroscopic parameters which in turn depend upon several factors, including patient size and desired image detail. The details of the procedure performed have a great impact upon patient dose. The final unit of import is the effective dose which is measured in Sieverts or miliSieverts (mSv).

Recently, the American Association of Physicists in Medicine (AAPM) released a statement that risks of medical imaging at patient dosages below < 50 mSv for single procedures or 100 mSv for multiple procedures are too low to be detectable and may be non -existent [9,10].

The purpose of this paper is to study whether using a protocol for performing MPVF can effectively decrease radiation dose in patients with VPI while providing the necessary information for planning surgical procedures for restoring velopharyngeal function in conjunction with FVNP. The methodology used for performing the imaging procedure will be described and discussed, as well as the use of this information for planning surgical procedures aimed to correct VPI.

2. Material and methods

This research was conducted at William Beaumont Hospital, Royal Oak, MI, USA. The project was approved by the Beaumont IRB (IRB # 2016-180). In May 2015, a TIMS - DICOM® system for videocapture was installed in the Section of Pediatric Radiology, Department of Diagnostic Imaging, Beaumont Health, Royal Oak, MI. The equipment allowed recording imaging studies with sound, calculation of radiation dose in mSv, brightness, contrast, rate and zoom controls. MPVF for evaluating velopharyngeal closure during speech was performed with this equipment in all cases of VPI. The following protocol was used:

1. In patients younger than 10 years of age, a story-book: "A Trip to the Hospital to Take my Pictures" [11] was given to the family a few weeks before the procedure. The story book explains what how the procedure is conducted. The objective is that the child will become familiar with the procedure and increase compliance. In older patients the procedure is carefully explained including a brief practice period of repeating the short speech sample.
2. The patient and the parent or accompanying person are allowed in the videofluoroscopy room. Lead aprons are provided.
3. The procedure was performed by a Speech and Language Pathologist who was familiar with the patient History and a Pediatric Radiologist. It should be pointed out that for this project all procedures were performed by the same Speech and Language Pathologist.
4. The procedure is carefully explained to the patient.
5. Liquid thick Barium is instilled through both nasal cavities with a 5 cc syringe and a pediatric feeding tube.
6. Coating of the pharynx is confirmed through intraoral examination.
7. The examination is performed with pulsed fluoroscopy.
8. All examinations were performed with the patient standing.
9. Magnification was never used in any of the cases. The TIMS - DICOM® system allows magnification in the recorded procedure.
10. The tower was kept as close to the patient as possible.
11. Coning was used to avoid radiosensitive structures such as the lens and thyroid.
12. The patient was asked to repeat a short speech sample as explained in the Story Book or practiced before the procedure depending on the patient's age. The speech sample included plosive and fricative sounds and high and low vowels in syllables, words and short sentences. It should be pointed out that before the procedure was scheduled a Speech and Language Pathology evaluation had to demonstrate that the patient was able to repeat the speech sample at least during syllables and words with adequate articulation placement without compensatory articulation errors.
13. PA, lateral and submentovertex views were obtained in all cases. Oblique views were used only in selected cases with asymmetric velopharyngeal movements.
14. Examination time was limited to <40 s. Velopharyngeal closure was not analyzed during the procedure. The examiners only made sure that velopharyngeal structures were clearly identified.
15. Examination of velopharyngeal movements during speech and measurements were performed from the recorded study. after the patient and family members had been discharged from the department.

The movements of velopharyngeal structures were analyzed separately as described previously [1,12–14] Velum motion, lateral pharyngeal wall motion and posterior pharyngeal wall movements during speech were analyzed as many times as necessary for a complete and reliable examination. The movements were assessed in slow motion or even frame-by-frame when necessary.

Moveable radiopaque markers were used to perform measurements on the recorded images. Magnification was not taken into account but considered minimal by keeping the fluoroscopic tower as close to the patient as possible.

For actual size measurements, the number of pixels between 2 marks was used as reference in order to obtain a ratio and measure distances in mm.

The following actual size measurements were obtained in every case:

1. Distance between the tip of the uvula and the hard palate at rest.
2. Distance between lateral pharyngeal walls at rest.