Evaluation of the Pituitary Gland Using Magnetic Resonance Imaging: T1-Weighted vs. VIBE Imaging

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SUMMARY – *Volumetric interpolated breath-hold examination (VIBE) is used for abdominal imaging as a fast and efficient modality. Evaluation of brain lesions using VIBE is not common and its use for the pituitary gland has not yet been addressed. Our goal was to compare coronal T1-weighted (T1W) and VIBE images in patients undergoing studies of the pituitary gland. We hypothesized that, for this purpose, VIBE is superior to T1W images. T1W and VIBE images of the pituitary gland in 32 patients were evaluated. The two sequences were compared with specific attention to: contrast enhancement (gland and cavernous sinuses) and ability to view the anatomy of the cavernous sinuses. In patients with macroadenomas, visualization of the optic chiasm was also assessed. Images were rated as: VIBE being better, equal, or worse in comparison to T1W images. We also compared VIBE and T1W images specifically looking at micro/macro-adenomas and post-surgical patients. Statistical analysis was performed using chi-square statistics. Of the 32 patients, the VIBE sequence showed superior contrast enhancement in 18 patients, six were found as being equal to T1W, and in eight instances VIBE was found to be worse than T1W. These results were statistically significant ($p=.02$). When looking at micro/macro-adenomas and post-surgical patients specifically, there was a trend to VIBE being superior to T1W but these data were not statistically significant. Visualization of chiasm in macroadenomas was similar for both techniques. VIBE was significantly superior to T1W with respect to pituitary and cavernous sinus contrast enhancement and cavernous sinus anatomy. A trend towards VIBE being superior in the evaluation of adenomas (pre- and post-operative) was seen, but it was not statistically significant. This is likely due to the small population size.*

Introduction

The modality of choice for evaluation of pituitary lesions is magnetic resonance imaging (MRI). Specifically, sagittal and coronal spin-echo (SE) T1-weighted (T1W) sequences provide useful information when evaluating this region especially after administration of gadolinium. The gland, its stalk, and the cavernous sinuses are best seen on coronal images¹.

An interpolated three-dimensional (3D) T1W gradient-echo (GRE) sequence, also known as volumetric interpolated breath-hold examination (VIBE) is widely used for abdominal imaging². This technique is useful because of its ability to acquire high quality data in relatively

short time frames. Imaging using 3D techniques is superior to standard two-dimensional techniques (2D) as used with conventional T1W sequences because of improvements in signal-to-noise ratio (SNR), thinner slices, fat saturation, and contiguous data collection^{2,3}.

Evaluation of brain lesions using VIBE has not been extensively looked at, specifically evaluation of the pituitary gland. Wetzel et al. compared VIBE imaging of the brain with standard 2D T1W imaging focusing on the brain as a whole. They found that VIBE was an efficient alternative for detection of lesions. Their study did not focus on the pituitary³.

The goal of our study was to compare coronal SE T1W and VIBE sequences in patients un-

Figure 1 Multiple SE T1 weighted (A,C,E) and corresponding VIBE (B,D,F) images at the level of the pituitary gland. A,B) Diffuse enlargement of the pituitary gland. C,D) A mass can be seen in the left aspect of the gland causing rightward deviation of the pituitary stalk. E,F) A mass with suprasellar extension. The images show the superior contrast resolution obtained with VIBE (B) imaging. The contrast enhancement of the mass and delineation of the cavernous sinus is improved with VIBE imaging. The post surgical changes seen in the sphenoid sinus (E,F arrow) are more clearly differentiated from the surrounding structures with VIBE imaging.

dergoing pituitary imaging. We hypothesized that VIBE sequences are better than T1W images for this purpose.

Methods

Data Acquisition

MRI was performed on 1.5-Tesla systems immediately after intravenous administration of a standard adult dose gadolinium-based contrast. Images were post-processed on a satellite workstation by a radiology technologist not involved with the data comparison. The VIBE

sequence was acquired as a 3D GRE sequence (9.96/3.69 [TR/TE]) with a field of view of 200×100 mm and slice thickness of 0.8 mm in coronal projection. Acquisition time was 3.32 minutes.

T1W images were acquired (370/14 [TR/TE]) with a field of view 100×100 and slice thickness of 3 mm. Acquisition time was 2.12 minutes. Although all patients all received dynamic post-contrast coronal fast spin echo T1W (3 mm slice thickness $\times$ 3), we chose not to compare these with the VIBE sequence as their spatial resolution is limited. In half the patients VIBE was done first after the dynamic post-contrast sequence and in the other half T1W imaging

was done first in an attempt to minimize the effects of delayed enhancement in our patient population.

Patients

Thirty-two patients (18 women; 14 men; mean age: 50.8 years; age range: 27-69 years) with variably elevated serum prolactin were evaluated. All patients were older than 18 years and had a clinical suspicion of pituitary lesions or had previously undergone resection of adenomas. Patients included those with micro/macro- adenomas and post-surgical patients. Of the 32 patients, nine were diagnosed with macroadenomas and five with microadenomas. Eight patients were post-surgical and ten had normal MRI studies.

Qualitative Assessment

Two radiologists subjectively assessed all images for quality of depiction of lesions, contrast enhancement (gland and cavernous sinuses), and anatomy of the cavernous sinus (ability to separate enhancing venous blood from cranial nerves and intracavernous carotid artery and ability to visualize its dural walls particularly the medial one). Visualization of the optic chiasm in patients with macroadenomas was also assessed. Discrepancies were resolved by consensus.

Statistics

A Pearson's chi-square test of goodness of fit was used to analyze the data as a whole and divided into microadenomas, macroadenomas, and post-surgical patients. The formula is as follows:

$$\chi^2 = \sum_{i=1}^n \frac{(O_i - E_i)^2}{E_i}$$

Expected values are those thought to support the null hypothesis: that VIBE and T1W images show no difference in contrast enhancement, lesion depiction, or cavernous sinus anatomy. A p-value less than 0.05 was considered statistically significant.

Results

Of the 32 patients evaluated, 18 were judged as showing superior contrast enhancement, lesion depiction, and cavernous sinus anatomy

with VIBE. Six were reported as showing equal contrast enhancement, lesion depiction, and cavernous sinus anatomy between VIBE and T1W imaging. Eight were reported as having poorer contrast enhancement, lesion depiction, and cavernous sinus anatomy with VIBE. Of note is that of the studies characterized as worse with VIBE imaging, three were due to motion artifact. These results were statistically significant under a chi-square test ($p=0.02$)

Adenomas were evaluated in 14 patients (microadenomas=5, macroadenomas=9). In patients with microadenomas all but one showed superior contrast enhancement, lesion depiction, and cavernous sinus anatomy with VIBE imaging. One VIBE study which was judged worse than the T1W study had a significant motion artifact. This was not statistically significant under a chi-square test ($p=0.17$). Of the patients with macroadenomas, five showed superior contrast enhancement, lesion depiction, and cavernous sinus anatomy with VIBE. In three, T1W and VIBE imaging were judged as equal and one was worse with VIBE imaging. These data were not statistically significant under a chi-square test ($p=0.07$). When data were evaluated looking at pituitary adenomas as a whole, these were statistically significant ($p=.01$). Macroadenomas were also evaluated for depiction of the optic chiasm. One study showed superior evaluation of the chiasm on the VIBE sequence and one showed superior evaluation of the chiasm with T1W imaging. The remainder were both equal in comparison. Cavernous sinus invasion by tumors was not seen in any patient.

Eight post-surgical patients also were evaluated. Of these, five showed superior contrast enhancement, lesion depiction (presumed to be recurrent/residual tumors), and cavernous sinus anatomy with VIBE imaging. One was depicted as worse and two were equal when comparing VIBE to T1W images. This was not statistically significant under a chi-square test ($p=0.07$).

Discussion

The potential for the VIBE sequence in the evaluation of the pituitary is great due to its very high anatomic resolution and relatively fast acquisition times. At our institution, slice thickness for VIBE is 0.8-mm compared to 3-mm for T1W imaging. Thus, a direct comparison between the two sequences is affected by

their inherent differences in slice thickness. Our study found that overall there was significant improvement in contrast enhancement and depiction of the anatomy of the cavernous sinus with VIBE. When VIBE was perceived as being worse than T1W imaging motion artifacts were the cause. We also found a trend towards a better visualization of adenomas using the VIBE sequence. In addition, we did not find a statistically significant difference between the sequences when evaluating post-surgical patients, a trend to better evaluation with VIBE was present. These last observations may be due to the small population size for each type of patient.

We chose not to compare the VIBE images with the post-contrast dynamic images. Dynamic images of the pituitary gland may be obtained with GRE, SE, or fast spin echo T1W images. GRE images are commonly affected by susceptibility artifacts from the sphenoid sinus and because of this, fast spin echo is used for them at our institution. Although these images provide exquisite physiological information (pattern of the pituitary stalk and gland enhancement) and may at times be more sensitive than other sequences for the discovery of small pituitary tumors, they tend to be slightly noisy and have lesser spatial resolution than other sequences. However, the fact that they may be superior to conventional SE T1W in certain clinical settings such as the evaluation of very small adenomas such as seen in Cushing disease has been well established in the literature^{4,5}. None of our patients had a suspicion for Cushing adenoma as all had variable elevations of prolactin. Our purpose here was to compare the technique that offers the highest resolution possible after contrast administra-

tion with the VIBE and we feel that this was the post-contrast coronal SE T1W. Another issue we attempted to control was the effects of delayed contrast enhancement. As time passes after contrast administration, some adenomas may enhance and the gland's enhancement may also wash out and diminish. We attempted to normalize these factors by obtaining VIBE first in 50% of our patients and T1W images first in the other half.

Cavernous sinus depiction was used here as a parameter because its tumor invasion affects the surgical goal and approach. The best sequence should be the one which most readily detects tumor extension in the sinus. In our limited experience we found that VIBE images showed greater cavernous sinus enhancement allowing for depiction of intracavernous structures and its dural walls. Although we had no adenomas invading the cavernous sinus we postulate that this greater degree of enhancement may make recognition of invasion easier but this remains to be proven. A potential caveat in this regard is that the cavernous portion of the internal carotid artery shows varying degrees of intraluminal enhancement on the VIBE images. However, this did not affect our ability to clearly separate it from the surrounding enhancing intracavernous venous blood.

Identification of the optic chiasm is important so that surgeons will avoid damaging it during surgery. In this respect, both T1W and VIBE perform similarly.

Like prior reports showing that VIBE as an efficient alternative to brain T1W imaging, our study showed that not only is it efficient, but in most cases, superior to T1W imaging⁶. Future studies with increased population size are needed to strengthen support for these results.

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