Breath-Hold Regulated Blood Oxygenation Level-Depedent MRI of Elderly Adults

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Introduction

Breath-hold regulated blood oxygenation-level dependent (BOLD) signal changes have been studied in young adults (1), but not in healthy elderly adults. To our best knowledge, the age difference in cerebrovascular response during breath holding has only been studied by vascular space occupancy (VASO) technique in a small group of subjects (2). In the present study, 3-Tesla BOLD MRI was applied to evaluate the cerebrovascular responses under repeated breath-hold challenges in healthy elderly adults and the results were compared with previous findings in young adults.

Method

Nineteen healthy adults (11 women, 8 men) aged between 50 and 77 years old (62.5 ± 8.5 years old) were recruited for this study. The body mass index (BMI) was in the range from 20 to 28 (23 ± 2). There was no hypertension, diabetes, cerebrovascular disease, cardiovascular disease, neurological disorder, or other major medical problems in these subjects. The breath-hold paradigm comprised of one preparation stage (30-second natural breathing) and three one-minute periodic breath-hold cycles (5, 10, 15, 20, or 30-second breath-hold periods). A total of 70 dynamic measurements were obtained. A single-shot T2*-weighted gradient-echo EPI sequence was applied for BOLD MRI: TR/TE = 3000/35 msec, flip angle = 90°, slice thickness = 5 mm, matrix size = 64 x 64, and in-plane resolution = 3 x 3 mm^2. An averaged signal-time course of subcortical gray matters (i.e. left thalamus) was used as the reference function. Pixels with significant changes in BOLD signal were then determined using a correlation analysis at the level of a corrective *P* value smaller than 0.05.

Results

End-tidal (ET) CO2, full-width at half maximum (FWHM), onset time, maximum signal change and fractional activation volume under different breath-hold conditions were summarized in Table 1. Significant BOLD signal increases could be detected in the gray matters for a breath-hold duration as short as 5 seconds (Fig. 1). The fractional activation volume vs. breath-hold duration reached a plateau at 15 second (Fig. 2). There was no significant correlation between maximum signal change and breath-hold duration (r^2 = 0.80, *P* = 0.041). The corresponding time courses of BOLD signal changes, end-tidal CO2 and respiratory pattern were shown in an example of 15-second breath-hold paradigm (Fig. 3).

Table 1 Breath-hold BOLD MRI at 3-T in normal elderly adults

	ET-CO2 (mmHg)	FWHM (sec)	Onset time (sec)	Max signal (%)	Activation vol. (%)
Pre-BH	31.80 ± 4.56				
5-sec BH	33.95 ± 3.11	13.34 ± 7.72	9.50 ± 4.12	1.07 ± 0.74	15.02 ± 13.26
10-sec BH	36.42 ± 3.78	12.45 ± 4.35	13.94 ± 1.68	1.61 ± 0.60	27.34 ± 14.45
15-sec BH	37.32 ± 3.39	14.13 ± 4.56	16.91 ± 1.38	1.97 ± 0.73	38.86 ± 17.15
20-sec BH	37.50 ± 3.67	18.17 ± 4.08	18.11 ± 2.55	2.03 ± 0.66	44.42 ± 16.11
30-sec BH	36.95 ± 3.54	23.94 ± 5.12	21.26 ± 5.71	2.19 ± 0.80	40.90 ± 18.71

Fig. 1 BOLD signal increases

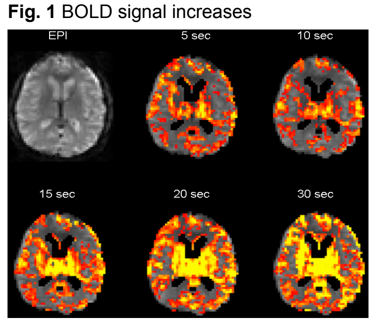


Fig. 2 A plateau at 15-sec

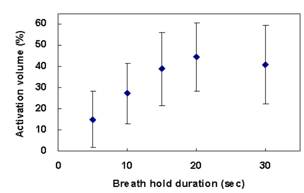
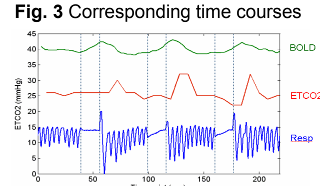


Fig. 3 Corresponding time courses



Discussion

This study showed that there were significant BOLD signal increases in cortical and subcortical gray matters for a breath-hold period as short as 5 seconds and the fractional activation volume vs. breath-duration reached a plateau at 15 seconds. These findings were similar to the results in a previous 3-Tesla study in young adults (1). However, almost all the fractional activation volume (27.34 % ~ 44.42 %) and the maximum signal change (1.61 % ~ 2.19 %) in the elderly group were smaller than the corresponding ones in young adults (34.16 % ~ 51.45 % and 2.47 % ~ 2.78 %, respectively) (1). Donahue et al (2), using VASO technique (3), showed that there was a more negative VASO reactivity in five elderly controls (-1.9 %) compared to five young controls (-1.4 %), but lack of statistical significance. Since BOLD and VASO signal changes are derived from different physiological phenomena, a large-cohort study combing these two MRI techniques may further elucidate the differential cerebrovascular response to breath holding between elderly and young adults.

References

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