The pattern of language deficits in neurosurgical patients[1]

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Introduction

Prior to a neurosurgical resection, most patients with tumors or epileptogenic foci in the left hemisphere of the brain show normal or close to normal language abilities. After the surgery, however, many patients present with significant language decline, which is often resolved over several months (Duffau et al. 2003). Previous studies report different rates of aphasia in the acute post-surgery phase, ranging from 17% to 100% (Papagno et al. 2012). The mechanism of postsurgical language deficits is not fully understood. Most studies that attempted to analyze postsurgical language outcomes used incomprehensive language testing (Davies et al. 2005); in others, subjective scoring of tests was extensively used (Wilson et al. 2015). We used the comprehensive and objectively rated Russian Aphasia Test (Ivanova et al. 2016) to examine the pattern of language deficits in the acute phase in patients who underwent a neurosurgery in the left hemisphere.

Method

A total of 30 monolingual native Russian-speaking patients (16 female; age range 18-63, mean 41 y.o.) with gliomas (primary brain tumors starting in the glial cells), cavernomas (blood vessel malformation forming a benign tumor), metastatic tumors or epileptogenic foci in left-hemisphere perisylvian language regions participated in this study. One patient was ambidextrous while all others were right-handed. All patients were operated on at the Pirogov National Medical and Surgical Center (Moscow) or the Federal Center for Neurosurgery (Novosibirsk), for the first time. Twenty-eight of them underwent awake craniotomy and intraoperative language mapping to minimize postoperative language deficits; two patients were operated under general anesthesia due to contraindications for awake craniotomies. In all patients, the goal of the surgery was to resect a pathological brain locus.

All patients were assessed with the Russian Aphasia Test (RAT; Ivanova et al. 2016), before and 1-8 days after the surgery (median=5). This battery consists of a series of tasks designed to assess both comprehension and production at all levels of linguistic processing. In this study, we focused on three basic levels – phonological, lexical and syntactic, in two modalities – comprehension and production. In comprehension, these were assessed using phonological judgment of minimal pairs of pseudowords; word-to-picture matching for objects and actions; sentence-to-picture matching for syntactic constructions of varying complexity. In production, we used repetition of pseudowords; picture naming of objects and actions; sentence construction in response to a picture. Test performance was measured in percentage of correct responses. We then compared pre- and postsurgical test results. Statistical analysis was performed using SPSS (Version 23).

Results

Presurgically, most patients performed well on language tests: 27 patients showed normal or close to normal language abilities; two patients showed mild deficit and one patient presented

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with a stronger language deficit. Postsurgical testing revealed that only 9 patients (27%) maintained or improved their language performance; others showed worsening. At the group level, production was affected significantly more than comprehension ($t(29)=3.24$, $p=0.003$): performance on language production tasks decreased by 21.4% (SD=30.1%), while performance on comprehension tasks decreased by 9.8% (SD=17.7%).

Changes in patients' performance on three chosen levels of linguistic processing (phonological, lexical and syntactic), in comprehension and production, were further compared. For that, difference between post- and presurgical scores on 6 aforementioned tests was calculated and entered pair-wise comparisons (p-values were corrected for multiple comparisons using the Benjamini-Hochberg procedure). No significant difference among comprehension tests was found. In contrast, in production, there were significant differences between all considered levels of processing: phonological vs. lexical ($t(29)=2.41$, $p= 0.031$), lexical vs. syntactic ($t(27)=2.27$, $p= 0.031$) and phonological vs. syntactic ($t(27)=3.13$ $p=0.012$). Interestingly, language worsening was more profound for higher level of processing when compared to lower levels: postsurgical scores decreased by 14.9% (SD=30.4%) on the phonological, by 23.4% (SD=32.7%) on the lexical, and 30.1% (SD=35.5%) on the syntactic task.

Additionally, we calculated pairwise correlations between postsurgical scores of the 6 tests. All except one were strong and positive (r ranging from 0.58 to 0.92; significant at the 0.001 level meeting a multiple comparison correction). To compare this pattern with typical post-stroke aphasia, we analyzed the same data of 30 randomly chosen stroke survivors from a different project. In this cohort, the correlation results were very different from the post-surgery group: patients with post-stroke aphasia showed correlations between functionally related linguistic levels – e.g., phonological perception correlated with word comprehension ($r=0.60$, $p=0.001$), word production – with sentence production ($r=0.77$, $p=0.001$).

Discussion

Though in the long-term perspective language recovery rate after neurosurgeries is high, in the acute post-surgical phase most of the patients exhibit decline in language abilities. These deficits do not follow the classical pattern of aphasias, where one can identify a specific locus of the deficit. Instead, all tests showed strong pairwise correlations, meaning that there are no dissociations between different language domains. At the same time, in speech production worsening was more profound for higher levels of processing than for lower levels. All in all, our results suggest that the observed deficits are rather non-specific in nature and are modulated by the cognitive load of the task. Future studies that would include lesional data and follow-up longitudinal studies are needed to further inform the nature of post-surgical language deficits.

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