2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

Estimation of Brain Lesions: Insights From Non-imaging Data

S. Sutoko, H. Atsumori, A. Obata, A. Nishimura, T. Funane, A. Kandori,
K. Shimonaga, S. Hama, and T. Tsuji, *Member*, *IEEE*

***Abstract*—Brain imaging measurement is one of the standard procedures for stroke patients whose lesions are located. However, this procedure is hardly carried out because of restless and/or claustrophobic patients. Another approach is required – estimating lesions based on only non-imaging data. We tried to model lesions using test variables related to mind-brain-body functions. The models brought 97 ± 2% and 62 ± 16% for estimation specificity and sensitivity, respectively.**

***Clinical Relevance*—This study provides a relatively practical method to monitor brain lesions even for challenging patients in the sites with minimum imaging facilities.**

I. INTRODUCTION

Impairments in stroke patients have been associated with brain lesions. Patients with lesions in the right Rolandic operculum were prone to worsened mental conditions.[1] Lesioned posterior lobes also brought decreased language, spatial, and executive functions.[2] By understanding these relationships, the appropriate rehabilitation can be suggested from an early stage. Due to a less viable imaging, the lesion information is not always acquired. Therefore, in this study, estimating lesions using only non-imaging data is aimed.

II. METHODS

One hundred ninety-five patients (158 males; 67 ± 10 years old) with cerebral infarction participated in this study during their rehabilitations at Hibino Hospital, Hiroshima. Informed consent was provided by all participants. This study was conducted in compliance with relevant regulations and the latest version of the Declaration of Helsinki.

T2-weighted brain images were collected from all participants. Lesions were visually evaluated by a proficient doctor (KS), and lesion degrees (in %) were analyzed afterwards.[3] Degree measures were obtained for 116 regions of the Automated Anatomical Labeling. Lesion degrees were converted to the categorical data – absence-presence (> 0%) or low-high (> threshold%). Thresholds were iterated within a range of 1–99% (1% steps).

Besides brain measurements, participants performed several standard batteries to assess their mind-brain-body functions. Two hundred forty-one variables were gathered in total. Estimation was modelled using the multivariate logistic regression. Variables were initially selected based on significant (Kendall's τ rank) correlations with lesion categories. Nested cross-validation (4*3-fold) and bootstrapping (100 times) were also performed during the modelling. Models and thresholds were chosen according to the lowest Akaike Information Criterion (AIC) values.

III. RESULTS

Figure 1 shows estimation performances (i.e., accuracy: true absence/low and true presence/high; specificity: true absence/low; sensitivity: true presence/high) across regions. High-performed estimation of low-high lesion categories was observed (96 ± 2%, 97 ± 2%, and 62 ± 16% for accuracy, specificity, and sensitivity, respectively). Optimum thresholds were found within a range of 1–48% across regions; the number of variables was varied from 3–31 (up to 13% of total variables). Subject deviations (D_{median}) highly associated with thresholds (Spearman's $\rho > 0.8$) but not with variable numbers ($\rho = 0.2$). Estimation models frequently used variables from tests of Cognitive Assessment Tool, Mini-Mental State Examination, Behavioral Inattentive Test, and Japanese Perceived Stress Scale.

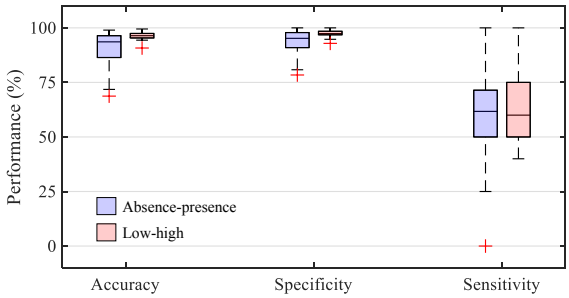

Figure 1. Estimation performances

IV. DISCUSSION & CONCLUSION

As mental-cognitive functions highly contributed to the lesion estimation, its relationship was consistently confirmed.[1,2] Rather than domain-specific correlations, lesion locations and degrees associated with multi-domain impairments.[4] The dataset per se had limited sample number for high-degree lesions and dissimilar lesion distributions across regions. These caused decreased sensitivities and varied thresholds. Nevertheless, the current study still delivers the useful understanding about lesions and mind-brain-body functions. Estimating lesions from non-imaging data and relatively simple tests also bring a benefit of early detection for stroke onset and/or recurrence. This approach expectedly supports clinical staffs to manage screening, patients' rehabilitations, and prognostic care more feasibly.

ACKNOWLEDGMENT

Abundant thanks to members of the Kaifukuki Rehabilitation ward, the rehabilitation department, the MRI team, the information management room and medical office secretary of Hibino Hospital, Hiroshima.

REFERENCES

[1] Sutoko, S. *et al. Sci Rep* **10**, 20264 (2020).
[2] Stoodley, C. J., *et al. NeuroImage Clin* **12**, 765–775 (2016).
[3] Shimonaga, K., *et al. Neurosur Rev* **44**, 977–985 (2021).
[4] Sagnier, S., *et al. J Stroke Cerebrovasc Dis* **28**, 1236–1242 (2019).

S. Sutoko is with the Center for Exploratory Research, Research & Development Group, Hitachi, Ltd., Tokyo 185-8601, Japan (✆: +81 42 323 1111, ✉: stephanie.sutoko.tc@hitachi.com). She is also a part of Department of Rehabilitation, Hibino Hospital, Hiroshima 731-3164, Japan.