A unified deep-learning network to accurately segment insulin granules of different animal models imaged under different electron microscopy methodologies

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KEY WORDS electron microscopy, deep-learning, segmentation, insulin granule, rhesus monkey.

The morphological and structural nature of insulin granules is important for their optimal function. Here, for the first time, we collected three-dimensional images of pancreatic beta cells in wild type (WT) and metabolic syndrome (MS) rhesus monkeys with a focused ion beam scanning electron microscope (FIB-SEM). To quantitatively and automatically analyze these large image datasets, we developed a novel deep-learning based algorithm, the multi-branch fully convolutional network (MFCN), which outperforms popular deep-learning algorithms and conventional machine learning algorithms by a large margin. The combination of multi-scale, multi-branch and fully convolution enables the MFCN to resolve insulin granules of distinct shapes and sizes, and offers good flexibility in the handling of electron microscopy (EM) of different modes. Finally, with the help of MFCN, we show that MS beta cells exhibit an increase in insulin granules at the price of reduced sizes in the granule and dense-core, which may provide insight into the pathogenesis of diabetes in humans.

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