Placenta as a Biomarker for Miscarriages: A Deeper Learning Approach

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NH-INBRE

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INTRODUCTION

- The placenta is a complex organ that plays a vital role in the development of the fetus. It is responsible for providing the fetus with oxygen and nutrients, as well as removing waste products. The placenta is also a barrier that protects the fetus from harmful substances in the mother's blood.
- The placenta can be affected by a variety of factors, including the mother's health, environmental exposures, genetic factors, and cancer. These factors can lead to changes in the structure and function of the placenta, which can in turn affect the health of the fetus and the mother, or lead to a miscarriage.

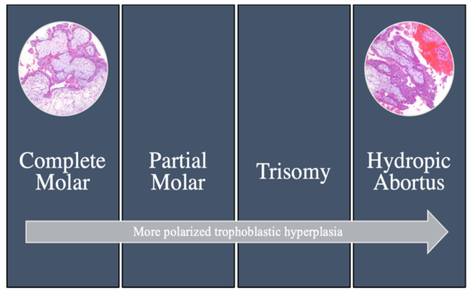


Figure 1: Modeling Histological Differences in Trophoblastic Hyperplasia Location among Miscarriage Causes on a Continuum.

- The placenta is a complex organ that is essential for the survival of the fetus. It is made up of three main layers: the syncytiotrophoblast, the cytotrophoblast, and the fetal blood vessels. The syncytiotrophoblast is the outermost layer of the placenta and is responsible for exchanging nutrients and waste products between the mother and fetus. The cytotrophoblast is the middle layer of the placenta and contains fibroblasts, placental macrophages, and blood vessels. The fetal blood vessels are the innermost layer of the placenta and carry blood from the fetus to the placenta.[3]

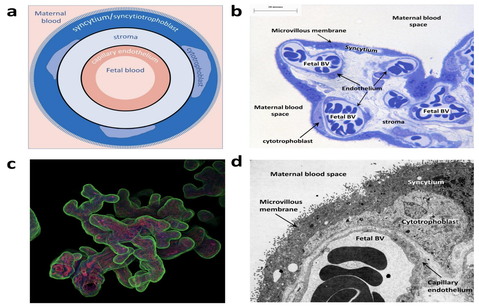


Figure 2: Cellular organization and structure of the human placenta, showing the three main cell layers between the maternal and fetal circulations.[2]

PROJECT OBJECTIVE

Villi algorithm to automatically detect and classify placental villi in whole slide images

- To develop and validate a machine learning model to predict the histological features of placentas from early miscarriages, with the goal of improving the diagnosis and treatment of miscarriages.

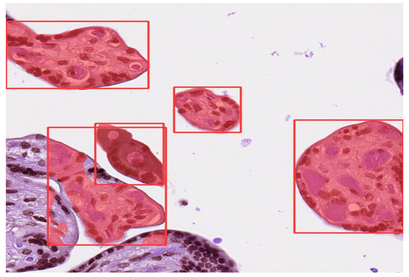
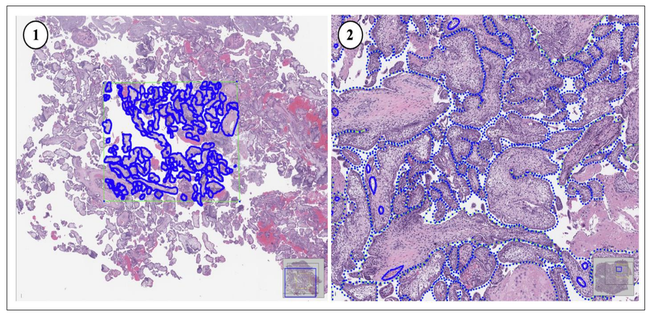


Figure 3: Annotations of villi in a placental tissue sample

METHODS

1. Annotations of Villi from WSIs



•**Figure 4:** Panel 1: Only a portion of each slide was annotated due to the presence of thousands of villi in slides with excellent histological features. Panel 2: Zoomed-in view showing vessels annotated within the villi.

2. Creating a Villi Algorithm

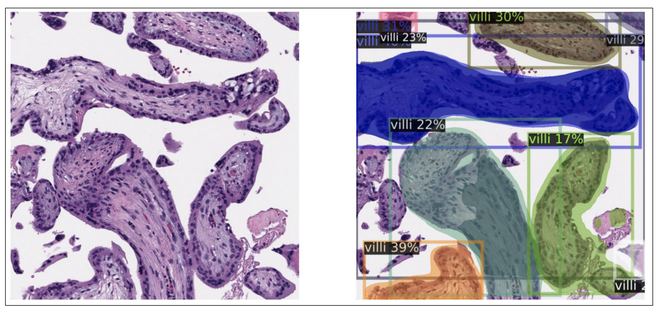


Figure 5: An example from the first round of testing the villi algorithm.

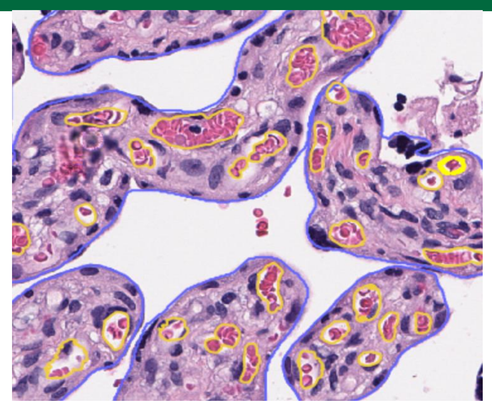


Figure 6: Annotations of blood vessels in villi represented by yellow circles

- Creation and curation of a dataset involving WSIs of placentas collected from patients at Dartmouth-Hitchcock.
- Curated dataset included 718 WSIs, with 23% having excellent histological features, 40% fair, and 37% poor.
- Trained a deep learning neural network to identify villi within WSIs using Decetron2 and later developed an algorithm for vessel location within villi.

FINDINGS

- Women with molar pregnancies, a type of cancer that develops in the placenta, often have abnormal placental villi. And Women who have had miscarriages are more likely to develop cancer later in life.
- Comparing different genetic origins of miscarriage (e.g., complete molar, partial molar, trisomy, triploid, aneusomy) with hydropic abortus provides valuable insights into diverse miscarriage types.[1]
- Incorporating the p57 test results for maternal genome presence can enhance the prediction of genetic composition in miscarriages.

DISCUSSION

In conclusion, our pioneering work on leveraging deep learning algorithms to analyze placental WSIs opens new horizons in miscarriage diagnostics. By quantitating and distinguishing subtle histologic features, we can streamline the identification of genetic abnormalities, minimizing the need for costly and invasive molecular analysis. This transformative approach not only enhances clinical efficiency but also offers renewed hope and support to couples navigating the challenging journey of miscarriage. As research in this field progresses, the integration of deep learning technologies into routine miscarriage diagnostics appears to be an auspicious avenue for improving patient outcomes and advancing our understanding of these complex reproductive events.

REFERENCES

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