Identification of Ovarian Follicles for Infertility Treatment

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Abstract

In recent years, the trend of people marrying later in life has been significantly increasing. In the US, 60% of married women in their 40s reportedly have infertility. In half of these cases, a female factor is the cause. As a consequence, infertility treatments are widely performed. One such treatment is in-vitro fertilization. This technique directly removes a follicle from the ovary and ovum is fertilized it with sperm under a microscope by embryologist.

Ovulation inducers can stimulate the growth of 10 to 15 follicles. However, 20% to 30% usually contain vacuoles and do not support ovary growth. In some cases, ova that are as much as 90% vacuolated do support ovary growth[1]. It thus cannot be determined whether a follicle has an ovum or is vacuolated unless the follicle is examined under a microscope. Consequently, it is useful to determine in advance whether a follicle has an ovum because follicle collection is painful for the woman. However, to date, a non-invasive method of identifying vacuolated ova does not exist. Therefore, we herein propose a method using ultrasound to determine whether a follicle has an ovum.

1 Introduction

Countermeasures to address a falling birthrate are urgent problems in Japan. Therefore, we herein elucidate the pathophysiology of human infertility. The objective of this research is to help increase the national birth rate by developing an infertility treatment method. Accordingly, we can help reduce the physical and financial burden on those striving to conceive a child. Some causes of infertility may occur on either the male side or the female side; however, not all imaging diagnoses can be provided using existing. The main cause of female infertility is lack of ovulation, oviducts (confinement, stenosis, adhesion), and lack of implantation. Treatment with reproduction assistive medical care includes ovulation induction, artificial insemination, and in-vitro fertilization.

In this study, we discriminated the ovarian follicle to target in-vitro fertilization that is necessary for fertilization. A vacuole that does not grow from the ovum is released from usually 20% to 30% of follicles. Therefore, it is not fertilized, even if the physician extracts from the ovary the follicle that is a vacuole. In addition, the follicle is extracted from inside the ovum using a collection needle, which is a painful procedure for the woman. Therefore, a method of diagnosing the follicle, including determining whether the ovum is present, is required. From that point, the burden on the patient is reduced by gathering only a follicle with an ovum.

In this study, we examined the possibility of distinguishing the ovum existence using ultrasound imaging. In addition, we employ a still image, not an animation, to distinguish it. This is because it must be processed in the shortest time period possible when the follicle is distinguished. Furthermore, the physician may mistakenly gather a vacuole but must not fail to obtain the follicle with an ovum.
2 Image overview

The procedure performed by the physician is depicted in Figure 1 [2]. A red part is an absorbed follicle.

The figure depicts the area around the cervix. The sac-like form connected to it is the ovary. A follicle is present in this ovarian part. It is generally classified by the existence or nonexistence of the ovum. Figure 2 illustrated an ultrasound image.

Fig. 1 Illustration of the uterus

Fig. 2 Ultrasound image of an ovary

The black part of Figure 2 is a follicle in which follicular liquid exists. We extracted a follicle part from these images and distinguished the ovum existence using the difference in brightness.

It is difficult to detect an ovum because it is very small at approximately 1/100 the size of the follicle. Therefore, we do not identify the ovum itself; rather, we focus on the change of the brightness around the ovum.

3 Extraction of the target domain

It is necessary to extract a follicular edge first to extract the follicle part that comprises the target domain. Some methods have already been suggested for extraction of this edge[3]-[5].

We used the determination of the center of gravity and border detection from these studies because the target domains are similar. A flow chart of estimating the center of gravity and border curve are shown in Figure 3. The result of the center of gravity is shown in Figure 4. The red line in Figure 4 denotes the border, while the red point is the origin.

Determine the temporary center of gravity

Expanded image

Differential image

Extraction of candidate points of border curve

Border detection using projection operator

Shifting the center of gravity

Bigger

Error of norm

Convergence

Estimation of the center of gravity and border

Fig. 3 Flow chart of estimation
4 Presence of ovum discrimination method

In this study, we used two kinds of distinction methods: determining the change of center of gravity based on the difference of brightness, and determining the histogram of brightness. It is difficult to detect an ovum when it is inside the follicle. It is believed that we can distinguish the follicle using the difference in brightness because the brightness of a hard part is more intense in the ultrasound image; the color changes from black to white.

4-1 Distinction by the histogram

The follicle within the ovum and the follicle extracted from the ovum are shown in Figure 5. The follicle inside the ovum is almost black, even if there is an ovum; thus, a difference between the two images is not apparent. Therefore, we created a histogram, which is shown in Figure 6. However, an embryologist confirms whether an ovum is included in a follicle with a microscope after ovum gathering.

Because part of the ovum was hard within the given portion of the follicle, we believed that the brightness of the domain was increased. However, a significant difference in the brightness of the two kinds of images was not evident. This was because it was accompanied by the echo decrement at a remote place from the neighborhood of origin of the supersonic beam sector.

In addition, the brightness of the region of interest was influenced before and after the organization. However, there was a monophasic peak in the image of around 30 brightness of the ovum. Therefore, we considered that brightness value was not different. Nonetheless, we believed there was a difference in the distribution of the brightness. Thus, we made a histogram using a different image (Figures 7 and 8). The histogram is shown in Figure 9. As a result, a remarkable single peak-related form was not apparent in the image with the ovum; it was thus difficult to use as an index.
Fig. 8 Image of follicle (another patient)

(a) Follicle within ovum (b) Follicle with ovum

4-2 Distinction using the center of gravity coordinate change

The proposed method involves progressively changing the upper brightness of 1 to 255. The method calculates the center of gravity coordinate each time. The brightness generally has the same distribution if the ovum is not included in the follicle.

On the other hand, it is thought that deflection of the brightness occurs partly when the follicle includes an ovum. In addition, we can reduce the influence of the precision of the edge when we sequentially calculate the center of gravity coordinate from a low brightness because the follicle brightness is lower than the brightness of the circumference. The reliability is higher than the histogram method with which we can evaluate only one image (we do not compare another image).

Figure 10 is the result of the change of the center of gravity on a follicle image. As a result, we understand that the position of the center of gravity moves to the lower right little by little. Therefore, there is a pixel having high brightness to a lower right part and can suppose that the part is tense. In other words, an ovum may exist. When an ovum was not included in the follicle inside, we were able to show that the center of gravity did not change even if we changed brightness because generally brightness distribution was the same. Including other images, we show the result that showed the change of the center of gravity in figure 11 and figure 12.

In each image with an ovum, the center of gravity of has changed. In one of the images without the ovum, almost no movement occurs in the center of gravity. In the other image, the center of gravity has moved.

Fig. 10 Position of center of gravity each brightness

(Red point is center of gravity of brightness 0-50. Green point is center of gravity of brightness 0-100. Blue point is center of gravity of brightness 0-150. Purple point is center of gravity of brightness 0-200.)

Fig. 11 Change of center of gravity

Fig. 9 Histogram of a follicle (another patient)

<table>
<thead>
<tr>
<th>brightness(level)</th>
<th>frequency(pixels)</th>
</tr>
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<tbody>
<tr>
<td>0-6</td>
<td>96</td>
</tr>
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Fig. 12 Change of center of gravity (another patient)

We can obtain all follicles that include an ovum by selecting the item in which the center of gravity changes. However, some empty follicles are also included. Using the proposed technique, the pain of the patient can be reduced.

5 Conclusion
In this paper, we proposed a technique of distinguishing the presence of the ovum in the follicle. Using only this method, it is not possible to make this distinction with high precision. Nevertheless, we believe that its use may be valuable. In future work, we intend to increase the number of cases to which we apply our technique to more effectively validate it. Furthermore, we intend to examine both still images and animation image obtained through a processing method.

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Reference