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Small Ultrasonic Linear-Array Probe to Support Endoscopic Surgery

内視鏡手術支援用小型超音波アレイプローブ

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1. Introduction

Endoscopic surgery is widely used to remove early-stage gastric cancer, because it is minimally invasive treatment for patients and does not require a long hospital stay. We are developing various devices used for endoscopic surgery in a project "Development of an on-site diagnosis and treatment system for reducing the physical load on patients" [1]. Before surgery for gastric cancer, lesion areas are examined using an endoscope, where an optical endoscope is used to examine the surface of the lesion area, and the inner area is diagnosed by ultrasonography. A mechanically-rotational ultrasonic probe is used, and although the echoes from the inner lesion area around the probe are obtained, the position of the cancer cannot be directly deterimined. A linear-array probe with electronic scanning is required to determine the position like the ultrasonic probes used outside the body. We have been developing a small linear-array probe to install in the channel of the endoscope. This paper discusses the efficiency of the experimental probe we fabricated with a diameter of 4.1 mm.

2. Design and Fabrication of Linear-Array Probe

There is a schematic of the linear-array probe used in this study in **Fig. 1**, and there is a photograph of the probe we developed in **Fig. 2**. It consists of ultrasonic transducer elements, a flexible neck and coaxial cables. It is installed in the channel of an endoscope. The purpose of our endoscopic ultrasonography is to diagnose early-stage gastric cancer of depth of around 1 mm to several millimeters; we selected a frequency of 10 MHz and an array pitch of 0.3 mm. The number of arrays needs to be as large as possible to examine wide areas of lesions, but this number is limited by the space in which transducer elements can be joined to coaxial wires and the number of coaxial wires that can be accommodated in the cable. We designed a maximum diameter for the probe of 4.1 mm, and 32 array elements. The total length of the transducer including the margins on the both sides was about 13.5 mm.

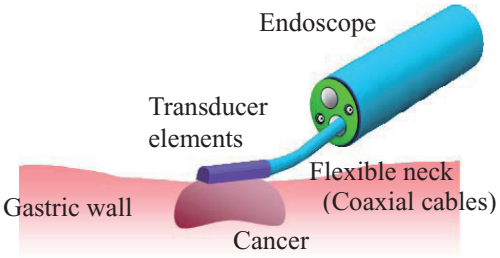

Fig. 1 Schematic illustration of linear-array probe for endoscopic surgery

Fig. 2 Photograph of linear-array probe

3. Image processing

We modified the pulser-receiver PAL 3 (Krautkramer Japan Co., Ltd.) to image the echoes from the lesion area. The ultrasonic beam was focused using an adjoining block of 4-6 elements in the 32 elements, and scanned the lesion area horizontally (X-direction) by shifting the elements one by one. Scanning in the Z-direction (depth) was done by changing the phase of the elements in the block (Dynamic depth focusing). We thus obtained pulse echoes in the A-mode and a 2-dimensional image in the B-mode. By translating the probe in the Y-direction, a 3-dimensional image can be obtained. Time controlled gain (TCG) processing was used to emphasize deep echoes,

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because ultrasonic pulses are strongly attenuated in the human body.

4. Ultrasonic images

The gastric wall of humans is composed of mucosa, submucosa, muscle (circular muscular layer, oblique muscular layer, longitudinal muscular layer), subserosa, and serosa, as shown in **Fig. 3** [2]. In a healthy body, these layers have clear boundaries with each other. When a cancer invades the gastric wall, the boundaries become unclear. Therefore, we first used the ultrasonic linear-array probe we had fabricated to observe the gastric wall of a healthy body. Part of a resected gastric wall was placed in a physiological saline solution in a vessel, and the ultrasonic linear-array probe was attached to the mucosa.

Fig. 4 shows the results of pulse echoes reflected from the boundaries in the A-mode. The pulse echoes from the deep boundaries were emphasized by TCG processing. **Fig. 5** shows a 2-dimensional (X-Z plane) image obtained by scanning with the 32 elements of the linear array probe. The layers of mucosa, submucosa, muscle (circular muscular layer, longitudinal muscular layer), and subserosa can be observed in this figure.

5. Summary

We developed a linear-array probe 4.1 mm in diameter to support endoscopic surgery. Each layer of a gastric wall was observed during diagnosis in the B-mode. The contrast can be improved by optimizing the conditions for imaging including those for TCG processing. We are also currently reducing the outer diameter of the probe to 3.5 mm to insert into the channel of 3.8 mm in diameter in the endoscope.

Acknowledgment

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References

1. http://www.shigaplaza.or.jp/area/
2. M. Okamoto, “Zusetsu jintai kaibougaku”, the 5th ed. Vol.2, p. 132, 2002, Igakusyoin [in Japanese].

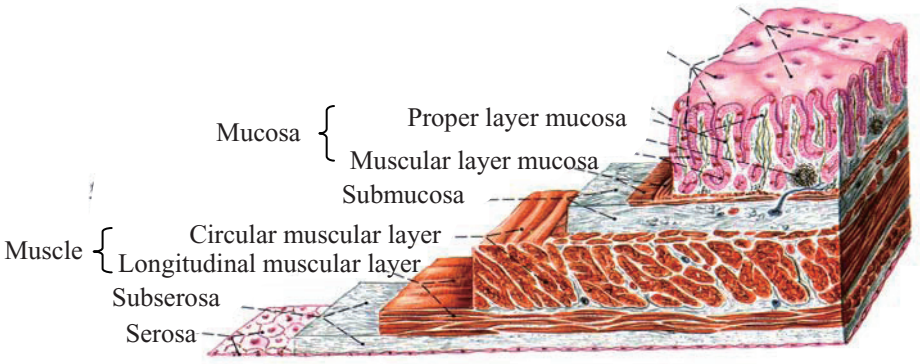

Fig. 3 Gastric Wall [2]

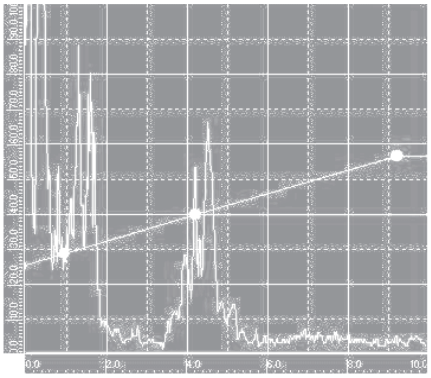

Fig.4 Pulse echoes (A-mode)

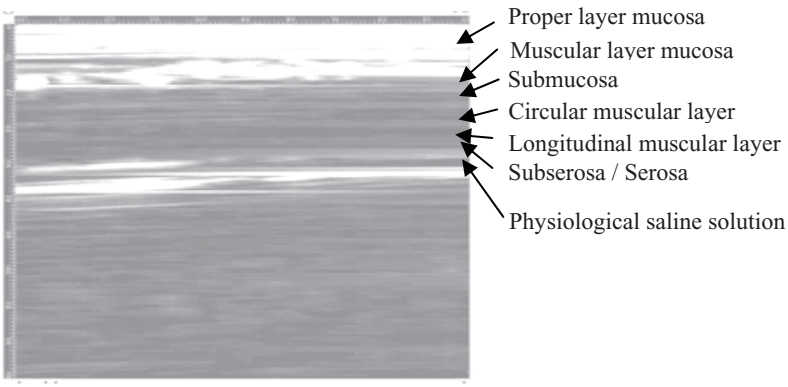

Fig. 5 Two-dimensional Image (B-mode)