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Thermal Dynamic Image Processing on Thermographic Endoscopy

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***Abstract*— The gold standard for evaluating the digestive disease is histology. We propose an original thermographic endoscope (TE) equipped real time image processing for evaluating gastrointestinal (GI) lesions. We have found that the transient thermal impulse response (TTR) by spraying cooling water reflected histological alteration in the GI lesion. Even if TE could not reveal any static temperature differences between normal mucosa and tumorous or inflammatory area, our prototype of TE could pick up the lesion clearly by mean of image processing applied dynamic subtraction technique to the alteration of TTR.**

***Clinical Relevance*— There are no endoscopic modalities except biopsy which can evaluate histological alteration due to digestive diseases. Our TE can contribute to estimate healing grades from the inflammation and qualify the malignancy of the tumor on site without biopsy.**

I. INTRODUCTION

The gut temperature namely core temperature is regulated by homeostasis and then it is very stable and monotonous. Therefore, to my best knowledge, most of medical researchers have not been interested in the application of thermography to digestive endoscopy. There is only one article presented on a thermographic probe which applied to observation of esophagus during ablation therapy against atrial fibrillation [1]. The present thermography has two drawbacks for applying it to endoscopy. One is accuracy smaller than 0.5 degree for detecting minute temperature changes generated by disease and the other is no visible image support for inserting endoscope and then there is no clinical report about TE. Our prototype TE overcame these drawbacks and equipped a new image processing which could enhance the difference of TTR.

II. METHODS

Original thermographic endoscope was composed of main three parts. The first was thermographic part, the second was traditional optical scope and the third was image processing unit. Thermographic camera (Seek thermal compact pro; USA) had been calibrated within 0.3°C just before endoscopy by a thermistor thermometer. TTR was measured by the following procedure, 1) set the endoscope camera in suitable position and focus on the target included the surroundings, 2) start video recording and timer, 3) spray the cool water over the visual field through the forceps channel.

The TTR curve was approximated by exponential curves

$$T_{tem}=Ta+(Tb-Ta)(1-\exp(-t/\tau_i)) \quad (1)$$

T_{tem}: temperature in time t, τ_i: proper time constant
Ta: temperature just after cooling
Tb: temperature before cooling

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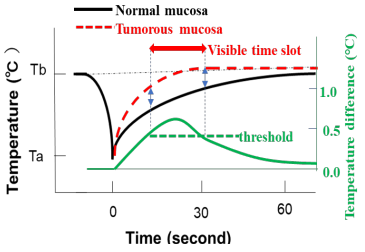

Fig.1 TTR and principle of processing

Table Time constants of TTR

Area	Time const. τi(sec.)
Normal	108
Tumor	62
Ischemia	88
*Matt's 1	123
*Matt's 2	150
*Matt's 3	186

*Matt's : severity of colitis

with time constants peculiar to each disease shown in Fig.1. The difference of temperature between normal and altered mucosa (green line) was derived from the equation (1).

III. RESULTS

Table shows the proper time constants of TTR related to each disease measured clinically by thermistor thermometer during the routine colonoscopy [2]. If the data set of a tumor in the table applied to the equation (1), we could identify the tumor between 12 to 30 seconds after cooling. Figure 2 shows the images of tumor depicted out by our TE with processing.

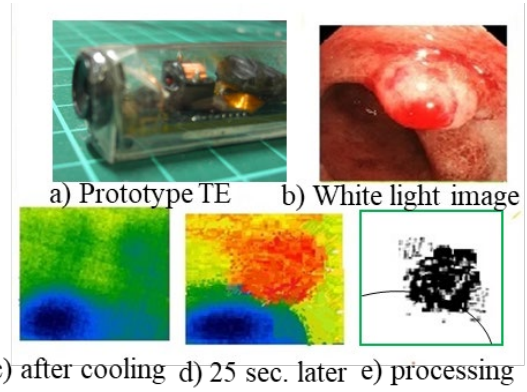

Figure 2 Prototype TE and its original and processed images using difference of TTR time constant.

IV. CONCLUSION

Thermographic endoscope is available for evaluating the severity and prognosis of the inflammation and qualifying tumorous lesions by thermal dynamic analysis. At the next step we will equip finer resolution camera and the AI software for characterizing the lesions automatically.

REFERENCES

[1] G.D. Matthew E, et al., "High-Resolution Infrared Thermography of Esophageal Temperature During Radiofrequency Ablation of Atrial Fibrillation" Circulation, Vol.11, Issue 2, Feb. 2018

[2] H. Ohta "Usefulness of thermo-endoscopy for evaluating the severity and prognosis of inflammationin the gastrointestinal tract" DDW2021 poster of distinction GIE Vol.93 No.6S. AB204-5 2021