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Risk diagnosis based on diameter of abdominal aortic aneurysm

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Abstract. An abdominal aortic aneurysm doesn't result in specific symptoms, and so providing a successful diagnosis can be challenging. Patients may require surgery for successful treatment, with the risk of aortic rupture being dependent on diameter. In this study, a CT screen of a patient with an aneurysm of the abdominal aorta was processed. In order to provide a more accurate and comfortable diagnosis, and to more easily determine the diameter of the abdominal aortic aneurysm, the Sobel and Top-hat methods were employed. Using a filtered screen overlap for the CT scan, the aortic diameter of a patient could be compared with the diameter of a healthy individual, thus allowing an immediate and accurate comparison. It was found that with a diameter of more than 40 mm the risk of rupture is higher.

Keywords: Abdominal aortic diameter, CT, Sobel, Top-hat, risk

1. Introduction

Abdominal aortic aneurysm (AAA) is the most common form of true aneurysm and the biggest cause of aortic rupture AAA rupture is the 15th leading cause of death in the United States, and amongst those aged 55 years or older is the 10th leading cause of death. Thus, AAA is considered to be a significant threat to public health [1–5]. Most diseases of the blood vessels are not apparent until the condition becomes really serious. Above all, an aneurysm of the abdominal aorta is a particularly dangerous disease. If a patient takes good care of their body and the disease is diagnosed early on, the patient can fully recover [6]. The main risk factors for an aneurysm of the abdominal aorta are smoking, genetics, age, and high blood pressure, amongst others. An aneurysm of the abdominal aorta doesn't show specific symptoms, so it can therefore be crucial that it is diagnosed early.

An aneurysm is generally defined by a diameter greater than 50% of the normal size of the blood vessel. For AAA, if the size is greater than 30 mm and the iliac artery is at least 18 mm, it is determined that there is an aneurysm. In males the thoracic aorta is usually about 28 mm, gradually becoming thinner under the renal arteries, to about 20 mm. In women the average size is about 2 mm less than in males. However, factors such as age and body surface area influence size variation. Most of AAA is larger until the aorta to show the form of a spindle, and if it has bag-shaped aneurysms and other deflecting

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-1	0	+1
-2	0	+2
-1	0	+1

Fig. 1. X kernel.

+1	+2	+1
0	0	0
-1	-2	-1

Fig. 2. Y kernel.

structures, it is known that high dignity of this rupture [5,7]. Nowadays, the disease is often treated using blood plastic surgery methods such as stent insertion whereby surgery is performed to insert a stent into the aorta at the aneurysm location.

The more people take an interest in their health, the more people care for their bodies and the more likely they are to prevent such diseases occurring. Nonetheless, a significant number of people will still continue to develop diseases such as AAA. Thus, it is essential that this disease be studied further in order to prevent its occurrence as well as to improve mortality and lifespan. Moreover, the disease itself can be very frightening to patients and the onset of pain can be rapid. Further still, an abdominal aortic aneurysm does not display clear specific symptoms, but if it leads to aortic rupture, the patient must receive immediate medical attention, since patients often die on their way to hospital [8]. The original method for diagnosis involved the use of the angle of blood or width area. In this case, doctors diagnose an aneurysm of the abdominal aorta via CT scan. When CT is observed, an aneurysm of the abdominal aorta displays differences when compared to a normal vessel. CT scanning is able to provide clear and accurate images so that these differences can be clearly observed. This study aimed to diagnose the disease condition through comparison of vessels from diseased patients with the diameters of normal vessels after CT imaging.

2. Material and method

The image processing techniques used for this study, were the Sobel Filter and Top-hat techniques [9–11]. The Sobel Filter technique is used for edge detection. Images can be viewed as a multivariate function with the X(Fig. 1), Y(Fig. 2) arguments. Therefore, X, because in the Y direction each may discontinuity point exists, according to each direction, two of the kernel exists. Sobel Filter kernel is as follows.

There are three methods to perform filtering. First, apply a kernel image in the x-direction, and calculate its partial derivative, and then calculate the partial derivatives in the y-direction by applying the y-direction kernel image. Both the partial differential values can be used to calculate the following Eq. (1).

$$S(x,y) = \sqrt{(D_x(x,y))^2 + (D_x(x,y))^2} \tag{1}$$

After performing the opening operation, the Top-hat technique was used whereby the difference of the result of the operation opening compared with the original image due to derived texture information of the video [12,13]. In other words, when the size of the filter is properly adjusted, the result of the

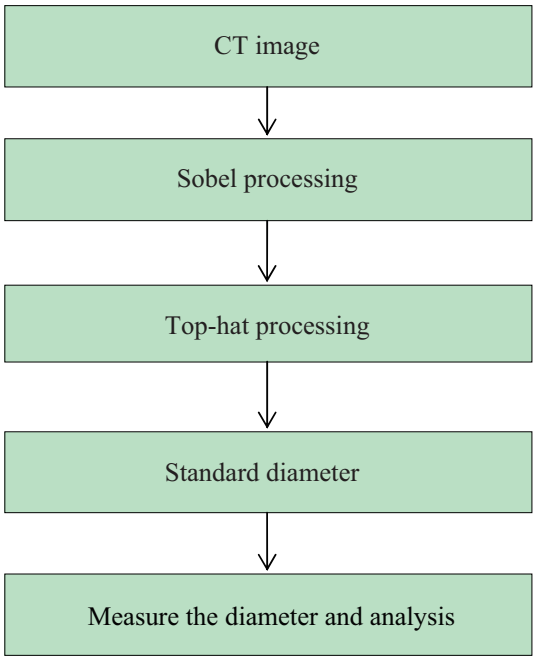

Fig. 3. CT image processing system.

opening operation, texture information such as character is deleted, because it remains in a form like a background image, and in comparison with the original video, and character is a technique that can be left only texture information, such as lines.

The method of the present study involves blood vessel imaging combined with overlap processing imaging of the diameter of normal patients as described above. The state of the patient's blood vessels is compared at a glance, by joining the magnification of the CT image by using Eq. (2), allowing the actual diameter of the vessel to be measured. The normal vascular diameter was used for the measurement, an average of a hundred subjects. Based on this, the average value was 17 mm. The normal diameter from CT imaging was 4 mm.

$$\text{Actual aorta diameter} = \text{Diameter of image process screen aortic measurement} \div \text{Diameter of CT imaging magnification (in this experiment, about } 0.25 - \text{ fold)} \ldots \quad (2)$$

An image processing flow chart of the present study is shown in Fig. 3.

In order to increase the accuracy of the study, average diameter size was derived from CT images and references of multiple recovery aortic aneurysm patients who recovered fully, beginning from 100 balls cadaver using the standard value of the normal vascular diameter, which is 17 mm. According to the CT images used in this study, there is a difference between the calculated actual blood vessel diameter and the average diameter found in normal subjects.

Five CT scan images (5 patients) of the patient were used to compare the image processing to accurately and quickly diagnose with the healthy CT images. The average value of healthy subject diameters was entered in proportion to the average CT imaging magnification, and the patient's blood vessel overlapping image was able to be grasped at a glance. Moreover, it has become possible to predict the actual approximate diameter of the aorta, which can be confirmed by CT scan.

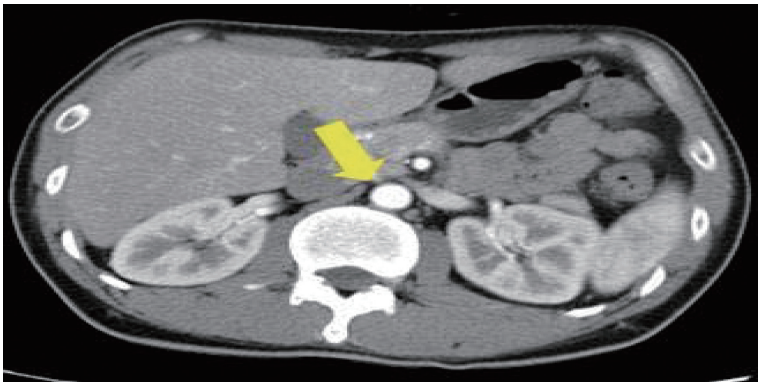

Fig. 4. Normal CT image.

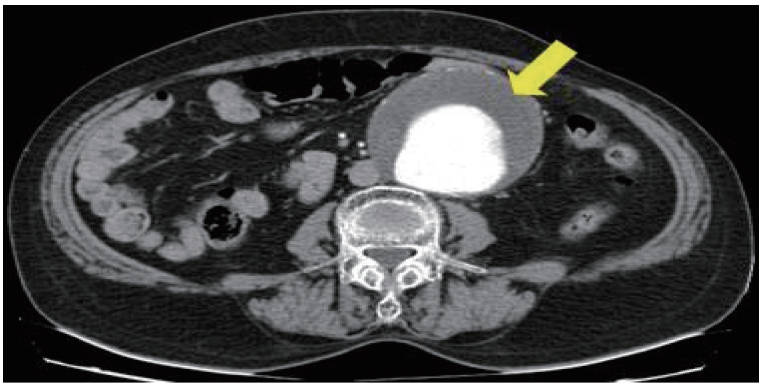

Fig. 5. Patient's CT image.

3. Result and consideration

In order to grasp the state of seriousness of the abdominal aortic aneurysm, five patients were compared by CT imaging through an algorithm validation study. Materials rupture stomach along the diameter based on, clean image processing techniques in is video, can be more easily visible to the naked eye, was studied so as to be able diagnosis is facilitated. The numerical standard diameter of a healthy subject is an average value measured from the bodies of patients as original references. Average diameter was found to be 110 mm, and the diameter was 17 mm. The following Fig. 4 shows a CT image from a healthy individual that has not been subject to image processing techniques.

The image from a patient can be seen in Fig. 5, displaying clear differences from the CT image of a healthy person. When looking at the area highlighted by the yellow arrow in the patient image and the image from the healthy individual, it is can be confirmed that the vessel was increased in size by about 5 times.

Figure 6 shows the image from Fig. 4 that has been subject to the Sobel Filter processing technique, and is sense to be clear and sharp. Looking at are where the yellow arrow is pointed in the Fig. 6, the Sobel Filter produces a clear outline of the area of interest, allowing the size of the blood vessel to be grasped easily using the naked eye.

After performing image processing with the Sobel Filter, the Top-hat image processing technique was then employed. The video that had been treated with Top-hat techniques in complement to technology

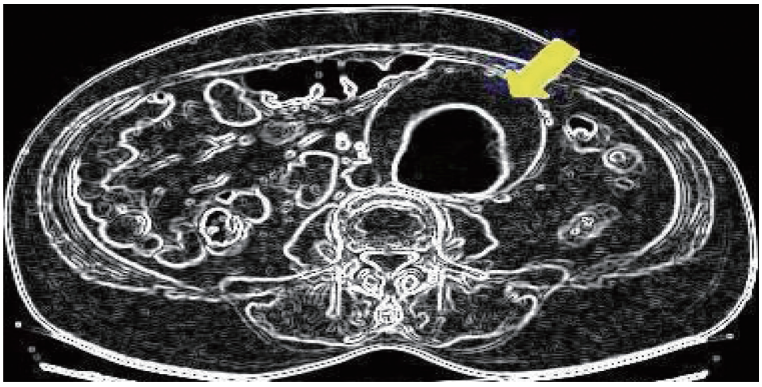

Fig. 6. The Sobel Filter processing of patient's CT image.

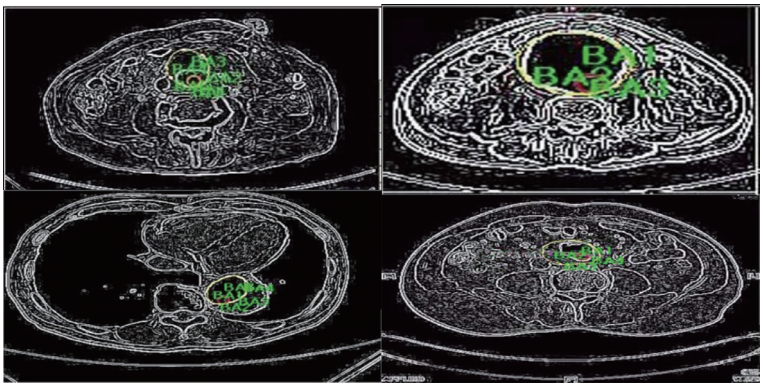

Fig. 7. The Sobel Filter and Top-hat processing of patient's CT image.

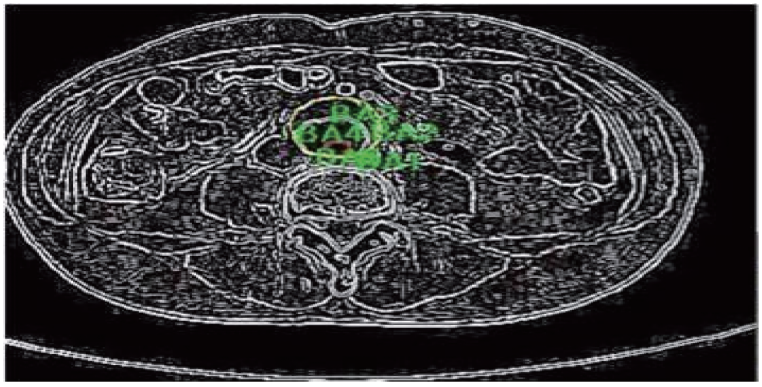

Fig. 8. Results of image processing.

missing contours work of Sobel Filter is able to observe the site of shapelier aorta to Sharp. Figure 7 shows a CT scan obtain after a Sobel Filter was applied followed by the Top-hat technique. The green area of the figure, shows how the aorta site is able to be found more clearly and easily.

Figure 8 shows the image obtained after performing all the image processing techniques followed by

Table 1
Analysis results

–	Value (mm)
Patient 1	25.77
Patient 2	27.90
Patient 3	28.35
Patient 4	27.61
Patient 5	17.30
SD	126.93
TD	50.7

overlapping with images from normal normal indivduals displaying a normal diameter. The size of the diameter from the healthy individual and the patient's aorta can be compared with using this CT overlap, with the healthy individual's aorta being easily identified with the naked eye.

After measuring the diameter, the value of the total diameter was then entered into the following formula for accurate verification of the actual diameter (Eq. (3)).

$$\textit{TD(Total diameter)} = \textit{SD(Sum of diameter)} \times 0.01 \div 0.25 \ldots \tag{3}$$

By using this expression, it was possible to determine the average value of normal subjects to be about 50.7 mm. Using the equations and methods described above, the diameters of each of subject listed consecutively from patient 1 to patient 5 were 25.77, 27.90, 28.35, 27.61, and 17.30. These exact values are shown in Table 1.

4. Conclusion

In this study, CT imaging of the abdominal aorta in patients with aortic aneurysm was performed using the Sobel Filter and Top-hat techniques. Images in these patients were compared with healthy subjects using CT image overlap for measurement of abdominal aortic diameter, for which I have developed an algorithm that can be uses to easily confirm diagnosis of abdominal aortic risk.

A standard diameter of 40 mm was produced based on 100 images of the bodies of healthy subjects. A diameter of less than or equal to the standard diameter of 40 mm indicates that there is almost no risk of rupture and a diameter of more than 40 mm indicates that the situation should be carefully managed due to the higher risk of aortic rupture. Using the Sobel Filter and Top-hat technologies allowed a clearer version of the original image to be produced. As a result, it becomes possible to evaluate the shape of the abdominal aorta with just a short glance. The total diameter from the processed image is not the actual diameter of the aorta, and thus the measured value needs to be converted using the following expression: TD(Total diameter) = SD(Sum of diameter) $\times$ 0.01 $\div$ 0.25. This exression will give the actual measurement of the aortic diameter. The algorithm used in the present study can not only be used for abdominal aortic measurements. It is believed that the image processing techniques employed in this study could be used as a diagnostic method for distinguishing cancer cases such as colon cancer.

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