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A Suggestion of New Integrated Prognostic Factor for Aortic Aneurysm: Tangential Stress Index

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1. 서 론

Partly because of increased longevity, the incidence of aortic aneurysm is also increasing[1]. Recent studies have shown that abdominal aortic aneurysms were detected in 4% of men and women between 65 and 80 years old and 11% of men aged 60 or over[2,3,4,5]. Anaortic aneurysm can be readily detected by measuring aortic diameter; dilatation of 50% or more than expected value, or that of the proximal segment, indicates its presence[6]. However, the rupture of an aortic aneurysm is a sudden crisis, and the aneurysm is seldom symptomatic before rupture[1]. In previous studies, 42 - 62% of cases of ruptured aneurysm resulted in the patient's death before reaching the emergency room[7,8,9]. Surgical mortality rates were reported to be between 32% and 70%[8,10,11]. The overall mortality of abdominal aortic aneurysm rupture is said to be around 80 - 90%[7,9,12]. Furthermore, because of multifactorial circumstances, it is not easy to detect a representative predictive factor for aortic aneurysm rupture.

By integrating blood pressure, aneurysmal luminal diameter, and wall thickness for the prediction of aortic aneurysm rupture and the guidance of proper practice, we have therefore attempted to establish a new basis for prognosis. In this study, we suggest that the tangential stress index of aortic aneurysm can be a useful prognostic factor for true aortic aneurysms.

2. 본 론

We studied nine cases of ruptured aortic aneurysm (men: women=5:4) and 40 cases of unruptured aneurysm (men: women=25:15). Anormal control group consisting of 42 subjects (men: women=22:20) with normal blood pressure and aortic features were also studied. Patients were aged between 24 and 85 (mean, 60) years. In both ruptured and unruptured groups, the most common location of an aneurysm was the infrarenal abdominal aorta. All patients and the control group underwent contrast enhanced CT (Hi-speed Advantage, GE, Milwaukee, U.S.A.) or EBT (Ultrafast CT C-150, Imatron, San Francisco, U.S.A.) to measure aneurysmal or normal aortic diameter and wall thickness. Twenty-eight patients and nine normal persons were scanned by spiral CT with 5-10 mm effective slice thickness and 1.0 pitch. The others were examined by EBT with scan parameters of 4 8 mm slice thickness, 0.1 0.2 second scan time and continuous volume mode. The EBT studies were performed prospectively, whereas the spiral CT studies were analyzed retrospectively. Approximately 80 100 ml contrast media (Ultravist 370, Schering, Berlin, Germany) was injected as bolus at a rate of 3 5 ml/sec.Either 5cc of 2% $MgSO4$ or test bolus (3-5cc) of contrast media was used to estimate circulation time. In the case of $MgSO4$, we measured the elapsed time between bolus injection into a superficial vein and awareness of a burning sensation in the throat.

Contrast-filled luminal diameters and wall thicknesses were measured at the portions of maximal diameter and the thinnest wall within the aneurysm. In the case of an elliptical-shaped lumen, the largest diameter was recorded. Wall thickness was measured at non-thrombosed and non-ruptured portions. In the case of an aneurysm with circumferential thrombosis, the whole thickness including the aneurysmal wall and thrombosis, was measured at the thinnest portion. These measurements were obtained at the maximally magnified images on the consoles or workstation (Insight, Accuimage, San Francisco, U.S.A.). For standardization, images were displayed in a wide window (over 1000 HU) and near the median level gray-scale. In patients without antihypertensive medication, blood pressures were measured at the time of scanning. The usual blood pressures were obtained from clinical records for either retrospective study, or prospective study with on-going antihypertensive therapy. Each systolic, diastolic or mean blood pressure was used as a pressure parameter.

To calculate the tangential stress of the aortic wall, modified Laplace's law was adopted. To correct the bias factor due to variability of normal aortic diameter according to aortic level and sex, the tangential stress index was induced by dividing each tangential stress value by the normal value. Normal tangential stress values were calculated on

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the basis of normal diameters, wall thicknesses, and blood pressures. Normal diameters of four aortic levels (midlevels of ascending aorta, aortic arch, intrathoracic descending aorta and infrarenal abdominal aorta) in both sexes were taken from published data. In this study, normal thickness of aortic wall was taken as 1.6 mm at all levels by averaging the thicknesses of normal aorta regardless of sex and aortic level. Aortic diameters were measured as normal for ages in the 4th decade, and normal blood pressure was thus assumed to be 120 / 93 / 80 mmHg.

Statistical analyses (one way ANNOVA range test and Fisher's exact test) were performed on both tangential stresses and tangential stress indices. To evaluate the effect of wall-thickness parameter on the results of this study, Laplace value (unmodified tangential stress) was also calculated and analyzed statistically. For comparison, diameter methods, representing the conventional approach, with a threshold of 4 cm and 5 cm, were applied to the same data group.

Maximal luminal diameters of ruptured aneurysms ranged from 40 to 80 (average, 59) mm, while those of unruptured aneurysms ranged from 24 to 83 (average, 43) mm. Average minimal wall-thicknesses of ruptured and unruptured aneurysms were 1.4 mm and 3.2 mm, respectively: average diastolic blood pressures were 95 mmHg (ruptured) and 84 mmHg (unruptured). Figure 2 shows tangential stresses (TS's) and tangential stress indices (TSI's) calculated using systolic, mean and diastolic blood pressures. The average values of each TS and TSI were also calculated. Average TS and TSI, calculated using diastolic blood pressure, were 1938 (4.13), 905 (1.84) and 554 (0.94) mmHg in ruptured, unruptured, and normal groups, respectively. Differences in diastolic TS and TSI among the three groups were statistically significant ($p<0.01$). Statisticalsignificance was also noted in other TS's and TSI's using systolic or mean blood pressures. ROC curves showed the usefulness of TS's and TSI's. Among TS's, the systolic TS curve showed the best ROC curve. With respect to TSI curves, mean and diastolic TSI's appeared to be more useful than systolic TSI. Mean TSI curve showed the best result. At a threshold of 1230 and 2.90 for diastolic TS and TSI, ruptured and unruptured aneurysms were readily differentiated. The sensitivity and specificity of TS (TSI) were 100% (100%) and 75% (88%), respectively. Positive and negative predictive values were 47% (64%) and 100% (100%) ($p<0.01$).

In the case of the diameter method, for fitting to maximum sensitivity (100%), the threshold should be decreased to 40 mm. The other scores were then 43% (specificity), 28% (positive predictive value) and 100% (negative predictive value). ROC curve analysis showed that the diameter method was less useful than TS(I) methods, although the curve was located in the "ordinary study" zone. By statistical analysis of Laplace values, with each threshold allowing maximal sensitivity (100%), systolic Laplace value was proved to be best, showing 70% specificity, 43% positive predictive value, and 100% negative predictive value. All diastolic, mean and systolic TS's and TSI's showed better statistical resultsand ROC curves than when the conventional diameter methodand unmodified TS(I) method were used. With regard to sensitivity, diastolic TSI showed higher scores than other TS's and TSI's.

3. 결 론

Tangential stress indices could be used as a more accurate prognostic factor of true aortic aneurysm than conventional methods. In particular, the diastolic tangential stress index could be the best predictor of aortic aneurysmal rupture, with emphasis on sensitivity. However, to eliminate limiting factors and to acquire a more accurate threshold value, further investigation of a large patient population is needed.

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