Pulse Characteristics of Abdominal Aortic Aneurysm and of the Femoral Artery Distal to It

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The advent of successful surgical treatment of abdominal aneurysm has increased the importance of detection and diagnosis of these lesions. The author has studied the pulse characteristics of abdominal aortic aneurysm and the distal femoral artery, and reports his results.

A NEURYSM of the abdominal aorta is of current interest because of its apparent increasing incidence, now occurring in at least 1.5 per cent of autopsies and its successful surgical management, which according to Wright was first reported by Dubost in 1951. The diagnosis depends on the presence of abdominal or back pain, on palpation of a pulsatile abdominal mass with or without tenderness, with or without a bruit, on x-ray evidence of a soft-tissue mass or calcification in the wall of the aneurysm, or, finally, on aortography. The width of the aneurysm as determined by palpation or x-ray is of prognostic significance, since only 4 to 18 per cent of aneurysms under 6 to 7 cm. in width found at autopsy have ruptured, as compared to 72 to 82 per cent of those over 6 to 7 cm. At present, the diagnosis of small aortic aneurysms is unsatisfactory, especially in obese patients.

There have been many references in the older literature to the effect of an aneurysm on the pulse distal to it. A decreased pulsation below the aneurysm was first described by William Harvey in 1628. According to Marey, this was also noted by Hodgeson and Broca, and by 1883 was a well accepted observation. Whittlesey refers to series by Hare and Holder, and Boyd and Kampmeir in which this finding was noted, and stated that it was a general postulate that aortic aneurysms reduce the amplitude of propagated pulses. Valleix, Weber, and Marey, in addition, believed that an aneurysm produced a delay in the presentation of the distal pulse. Marey constructed an artificial system whereby he transmitted a pulsation through a channel containing an aneurysmal pouch and recorded a pulsation of less amplitude and delayed peak force than when the same pulsation was transmitted through a serial channel of normal size. He compared these tracings with those of patients with subclavian aneurysms, which showed the same decreased amplitude and delayed peak in the radial pulse on the side below the aneurysm. He concluded that an aortic aneurysm would have these same qualitative changes, though to a lesser degree, because of its smaller size in relation to the size of the vessel. Whittlesey found in constructing an artificial saccular aneurysm of the aorta that a volume of 400 ml., which doubled the capacity of the system, was required to decrease the peripheral pulse below the central pulse. Wright, referring specifically to pulses below abdominal aortic aneurysm, found a diminished or absent pulsation below the aneurysm in 11 per cent. Marey also recorded the pulsation of the aneurysm itself, although it was necessary to record from the side of the aneurysm in order to attenuate the amplitude. He found the tracing resembled that of the carotid. Stokes believed that the timing of the aortic pulsation was of diagnostic significance in differentiating aortic aneurysms from abdominal

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pulsations in hysterical women and from some transmitted pulsations. There are no data on the transmission of the pulse wave in aortic aneurysms.

The purpose of the present study is to record pulsations over aortic aneurysms and femoral arteries distal to them and to determine if there are any alterations from normal in amplitude, form, or transmission time.

**Subjects and Methods**

Twelve patients were studied. Their abdominal aneurysms varied in size from 3 to 10 cm, in width, with 10 of the 12 less than 7 cm. Only 14 had symptoms referable to an aneurysm; 8 had abdominal pulsations; 2 had aneurysms found accidentally by x-ray for nonrelated conditions, and 2 had aneurysms found at operation for nonrelated conditions. Three of the aneurysms were saccular, 1 of these in association with a diffuse aneurysm. Seven young and 5 normal subjects between the ages of 50 and 70 were studied as controls.

Recording of the pulsations of the aneurysms and of the femoral arteries were made with a bellows pickup mounted on a crossbar, transformed by a piezoelectric transducer, and recorded on a 4-channel Sanborn 150 recorder. The apparatus was as described by Eddeleanu et al. for recording precordial movements.

Multiple tracings were taken along the course of the aorta, but no advantages were found over that of recording from a single point at the maximum pulsation as palpated. The tip of the pickup was pushed to the point of damping and then released until the maximum pulsation was obtained. The string settings were maintained constant, and the results were reproducible in the same patient on different days. In several obese patients it was necessary to have the abdomen depressed on each side of the pick-up by an assistant. The higher of the 2 femoral pulsations was used in the calculation.

The amplitude of aortic and femoral pulsations was measured as millimeter displacement on graph paper, with no determination of the actual displacement of the pick-up. The femoral/aortic ratio was calculated; the times were measured from the onset of the QRS of the electrocardiogram to the upstroke of the carotid, aortic, and femoral pulsations; the carotid and aortic pulsations were studied as to anacrotic time, "systolic time" (the time from onset of the upstroke to the incisura), and their ratio, and the level of the incisura above the end-diastolic level. The femoral pulsation was studied as to build-up time and "systolic time."

These were calculated as described by Kroeker and Wood.9

**Results**

The range of amplitude of the aneurysms was 80 to 1,200 mm., that of the normal cases was 3 to 370 mm., with 5 cases of aneurysm and 5 normal cases falling in the 80 to 370 mm. overlap range.

Femoral pulsations distal to the aneurysms averaged 170 mm. (range of 50 to 370 mm.) as compared to the averages in older normal subjects of 145 mm. (range of 28 to 280 mm.) and in young normal subjects of 166 mm. (range of 30 to 260 mm.).

The ratio of femoral to aortic pulsations was more than 1.0 in all the older normal subjects, in 5 of 7 young normal subjects, and in only 1 of 9 patients with aneurysms. Of the 7 patients with aneurysms but without clinical peripheral vascular disease, 5 had femoral/aortic ratios between 21 and 26 per cent.

The onset of QRS to carotid upstroke averaged 0.13 second with a range of 0.10 to 0.15 in the patients with aortic aneurysms, 0.12 with a range of 0.10 to 0.15 in the older normal subjects, and 0.13 with a range of 0.11 to 0.14 in the younger normal subjects. The onset of QRS to the abdominal aortic upstroke was 0.16 with a range of 0.11 to 0.18 in the patients with aneurysms, 0.16 with a range of 0.13 to 0.19 in the older normal subjects, and 0.18 with a range of 0.17 to 0.20 in the younger normal subjects. The onset of QRS to the femoral upstroke was 0.17 with a range of 0.13 to 0.20 in the patients with aneurysms, 0.18 with a range of 0.14 to 0.21 in the older normal subjects, and 0.21 with a range of 0.18 to 0.22 in the younger normal subjects. The time from the carotid upstroke to the femoral upstroke averaged 0.04 second in the patients with aneurysms, 0.06 in the older normal subjects, and 0.08 in the younger normal subjects. The transmission time from onset to femoral pulsation to onset of dorsalis pedis pulsation in 1 older normal person was 0.06 second, and in 1 young normal subject was 0.13 second.

The aortic pulsation resembled the carotid in configuration and had the same character-
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istics. The anacrotic time was 0.04 to 0.07 second; the systolic time in patients with aneurysm averaged 0.25 with a range of 0.22 to 0.29; in older normal subjects it was 0.25 with a range of 0.21 to 0.28 and in younger normal subjects was 0.28 with a range of 0.25 to 0.32. There was no variation in the anacrotic time or systolic time between the abdominal aortic and carotid pulsations in any given patient. The ratio of anacrotic time to systolic time varied from 14 to 27 per cent in patients in all groups. The build-up time and systolic time in the femoral arteries were the same for patients with aneurysms as for the normal subjects. The height of the incisura from end-diastolic level varied from 40 to 80 per cent of the total amplitude in the carotid, and 25 to 60 per cent in the abdominal aorta.

There were no differences in any respect between the 3 patients with saccular aneurysms and those with diffuse aneurysms of the aorta.

Discussion

This study failed to demonstrate any consistent effect of an aortic aneurysm on the pulsation below the aneurysm in amplitude, form, or transmission time of the pulsation. Because of the wide range in amplitude of the femoral pulsations, however, it cannot be proved that in any given patient the amplitude was not decreased from what it would have been if the aneurysm had not been present. There were no characteristics of the aortic pulsation, either in location, contour, or otherwise, that would be of diagnostic value. The amplitude of the pulsation was greater than in the normal subjects and showed a rough correlation with the size of the aneurysm, but there was a significant degree of overlapping of the normal and aneurysm groups. No pressure measurements were taken inside the aneurysm, and it cannot be determined if the increased amplitude reflected an actual increase in lateral pressure due to decreased velocity and subsequent increase in pressure in accordance with Poiseuille's law, or if the intravascular pressure were normal but produced a greater displacement due to increased distensibility of the vessel wall, or by acting over a larger surface area. It is of interest that 5 of 7 patients with aneurysms had a femoral/aortic ratio of 21 to 26 per cent. A larger number of patients is necessary to determine whether or not this is a significant correlation.

The figures for transmission time from onset to QRS to onset of femoral pulsation correspond to those found in young normal subjects by Schnabel et al.\textsuperscript{10} (0.205 second), The values for the older groups were 0.17 and 0.18 second, which are consistent with the increased pulse wave velocity known to occur with age. The systolic time was found to be shorter than the 0.275 to 0.306 or the 0.296 to 0.321 range obtained by Lombard and Cope\textsuperscript{11} and Kroecker and Wood,\textsuperscript{9} respectively. There was a difference in systolic time between the young normal subjects and both older groups, with a shorter systolic time not related to heart rate in the older groups.

Summary

Pulsations were recorded over 12 abdominal aortic aneurysms and over the femoral arteries distal to the aneurysms. The tracings were analyzed and compared to the carotid pulsation of the same subject and the pulses of normal old and young subjects.

The amplitude of the abdominal pulsation was increased in the patients with aneurysms but there was a significant degree of overlapping with the normal subjects.

The femoral/aortic ratio was almost always greater than 1.0 in the normal subjects, was less than 1.0 in patients with aneurysms, and in 5 of 7 instances the femoral pulse was one fourth to one fifth of the aortic pulse.

There was no demonstrable effect of the aneurysm on the femoral pulsation below, either in respect to amplitude, contour, or velocity of transmission of the pulse wave.

Pulsations of saccular aneurysms showed no significant differences from those of diffuse aneurysms.

These studies have revealed no demonstrable
advantage of recording abdominal and femoral pulsations in cases of suspected aneurysm, as compared with manual palpation and appropriate x-ray studies.

**SUMMARIO IN INTERLINGUA**

Le pulsationes esseva registrate supra 12 aneurysmos del aorta abdominal e supra le arterias femoral a sitos distal con respecto al aneurysmos. Le registrationes esseva analyzate e comparate con le pulsation carotidic del mesme individuos e con le pulsation de normal subjectos juvenes et aniantiate.

Le amplitude del pulsation abdominal esseva augmentate in le patientes con aneurysmos sed il existeva un area significative de coincidentia del scala de valores in iste patientes con le scala del valores in subjectos normal.

Le proportion femoral/aortic esseva quasi semper supra 1,0 in le subjectos normal. Illo esseva infra 1,0 in le patientes con aneurysmos, e in 5 ex 7 casos le pulso femoral esseva inter un quarto e un quinto del pulso aortic. Esseva constatate nullle effecto demonstrabile del aneurysmo super le pulsation femoral plus in basso, e isto valeva con respecto a amplitude, al contorno, e al velocitate transmissional del unda del pulso.

Le pulsation de aneurysmos sacculaire non exhibiva ulle differentia significative in comparison con le pulsation de aneurysmos diffuse.

Iste studios ha revelate nullle demonstrabile advantage de registrar pulsationes abdominal e femoral in casos de suspicione de aneurysmo, comparate con le methodo de palpation manual e del appropriate studios roentgenologico.

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