Occlusion of Peripheral Arteries
A Study of 6,400 Working Subjects

By L. K. Widmer, M.D., Ph.D., A. Greensher, M.D., and W. B. Kannel, M.D.

Detailed information concerning the prevalence and symptomatology associated with occlusions of peripheral arteries has largely been derived from the study of hospitalized patients or subjects with symptoms severe enough to require medical attention. Even such clinical studies have been few in number.1-5 Thus, occlusions of peripheral arteries are generally believed to be a rare and isolated disease, occurring exclusively in old people, presenting with classical symptoms, and without importance except for the limb involved. The purpose of this report is to describe the prevalence, age distribution, site, and symptoms of peripheral arterial occlusions in a working population and to compare them with those in clinical groups. The preventive implications of the findings are briefly considered.

Methods
A group of 6,437 volunteers from the workers and staff members of four Basle pharmaceutical companies were studied for data concerning the circulation, especially in peripheral arteries. Details of the sampling procedures and the response to the invitation to participate have been previously reported.6

The clinical examination included a cardiovascular history, determination of weight, height, blood pressure, and pulse wave velocity. Serum lipids and other chemical data have been determined on 2,900 subjects up to the time of this report by Hartmann, Creux, and Reber.7, 8 In order to facilitate the handling of the large amount of data observations were stored on IBM 729/V tape units and processed by an IBM 1401 computer.

Screening for occlusions of limb arteries included questions for claudication, for symptoms of ischemia of the skin, palpation, and electronic pulse recording. The pulses were recorded by an oscillograph with semicircular pressure cuffs placed at the dorsum of the feet, at the ankles, and at the wrists and inflated successively to 150, 125, 100, and 75 mm. Hg. In subjects with patent arteries, the pulses of symmetrical sites are of equal amplitude and show a sharp peak. Narrowing or occlusion of an artery decreases the pulse pressure and causes differences in amplitude and wave form (fig. 1).

A detailed examination was performed on 294 subjects with a doubtful or definite history and palpatory or oscillographic findings suggesting pathology. This included electrocardiogram, chest x-ray, and complete blood count. Skin blood flow was evaluated by Ratschow's postural change test and Na24 build-up.12, 13 Muscle blood flow was assessed by a walking test and tissue clearance of Na24.14 Aortography was performed on 83 subjects with oscillographic or auscultatory criteria of occlusion.15*

Results
Observations in this working population are contrary in many points to general beliefs that occlusion of peripheral arteries is a rare and isolated disease, occurring exclusively in old people, in the lower extremities, presenting with classical symptoms, and without importance except for the limb involved.

Frequency of Occlusions of Peripheral Arteries
Oclusions of peripheral arteries were found in 99 extremities in a total of 75 subjects; in 11 of 1,550 women and 64 of 4,887 men examined. Occlusions of peripheral arteries occurred with the same frequency in the two sexes at 15 to 39 years of age. In the age group 40 to 64 years the sex ratio was 1.6:1; i.e., the male predominance was less

* Aortography by Dr. H. Ludin and Dr. P. Waibel.
striking than that reported for patients with clinical occlusions of peripheral arteries: Hasse 3:1, Ratschow 3:1, Hines 6:1, Schadt 7:1, Juergens 11:1.16-17 Estimates of the sex ratio in the younger age group may be inaccurate due to the relatively small number examined. The sex ratio of the older group (1.6:1) on the other hand corresponds almost exactly to the ratios reported for coronary heart disease by population and autopsy studies.18-21

Since the number of women with occlusions of peripheral arteries was small, further analysis was restricted to men.

Age Incidence of Occlusions of Peripheral Arteries

About 0.1 per cent of men between 15 and 39 years, 1 per cent between 40 and 49, and 6 per cent between 55 and 64 presented occlusions (table 1). The prevalence of occlusions of peripheral arteries in hospitalized and working subjects differed in several aspects. Among working subjects of 40 to 59 the prevalence of occlusions of peripheral arteries was higher, but for the group 60 to 64 years of age it was almost equal to that reported for hospitalized subjects.22 The percentage of subjects with occlusions of peripheral arteries increased steadily up to age 64; in hospitalized subjects, after an increase to 52 years, the prevalence of occlusions of peripheral arteries decreased with more advanced age. This type of age distribution could be the result of selective factors, since a reputable, specialized clinic very likely attracts younger subjects from a large geographic area, whereas older subjects with occlusions of peripheral arteries accept the disease more fatalistically and less often seek medical assistance outside of town.

Similar selective processes may influence other data, such as the sex ratio. Men are more often insured than women and as a consequence their illness is more readily

Table 1

Prevalence of Occlusion of Peripheral Arteries—Basle Study

<table>
<thead>
<tr>
<th>Age, yr.</th>
<th>No. examined</th>
<th>OPA, %</th>
<th>No. examined</th>
<th>OPA, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-19</td>
<td>177</td>
<td>—</td>
<td>118</td>
<td>—</td>
</tr>
<tr>
<td>20-24</td>
<td>256</td>
<td>0.4</td>
<td>330</td>
<td>—</td>
</tr>
<tr>
<td>25-29</td>
<td>479</td>
<td>0.4</td>
<td>282</td>
<td>—</td>
</tr>
<tr>
<td>30-34</td>
<td>704</td>
<td>0.1</td>
<td>215</td>
<td>—</td>
</tr>
<tr>
<td>35-39</td>
<td>769</td>
<td>0.4</td>
<td>193</td>
<td>0.8</td>
</tr>
<tr>
<td>40-44</td>
<td>654</td>
<td>0.9</td>
<td>129</td>
<td>—</td>
</tr>
<tr>
<td>45-49</td>
<td>659</td>
<td>0.9</td>
<td>106</td>
<td>0.9</td>
</tr>
<tr>
<td>50-54</td>
<td>547</td>
<td>3.6</td>
<td>92</td>
<td>2.1</td>
</tr>
<tr>
<td>55-59</td>
<td>347</td>
<td>5.2</td>
<td>37</td>
<td>2.6</td>
</tr>
<tr>
<td>60-64</td>
<td>153</td>
<td>7.5</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Figure 1

Oscillographic criteria of arterial narrowing. Above. Aortogram of a 54-year-old woman with narrowing of the left common iliac artery and patent femoral, popliteal, and tibial arteries. Below. Corresponding pulse recordings in the ankle (left) and in the foot (right). The peaks are rounded and the amplitudes smaller on the left side (lower) than on the healthy right side (upper).

Circulation, Volume XXX, December 1964
brought to medical attention, with a resulting overestimate of male prevalence in clinical studies.

**Location of Occlusions of Peripheral Arteries**

Oclusions were noted in 87 extremities of 64 men. There was no tendency to lateralize to either side, with 40 occurring on the left and 46 on the right. Occlusion of the abdominal aorta just proximal to the bifurcation was noted in one subject. The distribution of occlusions in the lower extremities corresponds to that reported by clinical studies: 49 per cent in the superficial femoral artery, 23 per cent in the arteries of the lower leg, and 14 per cent in the iliac arteries. Occlusions in the upper extremities occurred six times more frequently (12 per cent) than reported in clinical studies. This discrepancy probably occurs because these occlusions cause less discomfort and disability than those in the lower extremities and consequently seldom lead to hospitalization.

**Symptoms of Occlusions of Peripheral Arteries**

At the screening examination two thirds of the subjects with occlusions of peripheral arteries presented no complaints. Even after detailed examination almost one third of the patients with occlusions of peripheral arteries presented no intermittent claudication or symptom of ischemia of the skin (fig. 2). This is in sharp contrast to reports on subjects with clinical occlusions of peripheral arteries, who almost all had symptoms severe enough to cause them to seek medical attention.

**Figure 2**

*Symptoms suggesting occlusion of peripheral arteries in subjects with and without occlusions of peripheral arteries. Feeling of coldness in legs or feet and other complaints (paresthesia, tingling, burning sensations) are frequent in subjects without occlusions of peripheral arteries (left). On the other hand 30 per cent of the 64 men presenting occlusions were symptom-free (right).*

**Figure 3**

*Aortogram of a symptom-free subject. Bilateral occlusion of the superficial femoral artery. This 51-year-old worker presented no symptoms referable to either leg, despite habitual walking of great distances during work and in his spare time.*
OCCLUSION OF PERIPHERAL ARTERIES

Circulation in spite of bilateral occlusion on the femoral artery. The frequency of a symptomatic occlusions of peripheral arteries is quite comparable to autopsy studies in which 30 per cent with demonstrated coronary artery occlusions had no symptoms prior to death.\textsuperscript{21} Not only is the history of subjects with occlusions of peripheral arteries often negative for ischemic complaints, but it may also mislead, spuriously suggesting occlusions of peripheral arteries. In fact 20 per cent of men and 37 per cent of women presented no signs of occlusions in the clinical examination, but complained of discomfort in the legs (paresthesia, feeling of coldness, tingling) (fig. 2).

Relation of Occlusions of Peripheral Arteries to Generalized Arterial Disease

Only 5 per cent of the occlusions of peripheral arteries subjects presented evidence of inflammatory arterial disease. All the other occlusions were on an atherosclerotic basis.

Evidence of extensive arterial involvement was frequent: 41 per cent of the men with occlusions of peripheral arteries had occlusions in more than one extremity. About 90 per cent presented arteriographic evidence of atherosclerosis in nonoccluded arteries of the pelvis and extremities, and 27 per cent had symptoms of coronary heart disease. Extensive, general arterial involvement is still more frequent in patients hospitalized for occlusions of peripheral arteries, occlusions involving more than one extremity having been reported in 47 per cent\textsuperscript{2} and concomitant coronary heart disease in 70 to 80 per cent.\textsuperscript{20,27}

Several further observations indicate that the importance of occlusions of peripheral arteries is not limited to the extremity involved: the age and sex distribution of coronary heart disease and occlusions of peripheral arteries are very similar (fig. 4); the prevalence of coronary heart disease is higher in subjects with occlusions of peripheral arteries. While a 6.4 per cent prevalence of coronary heart disease is reported for a male population of this age distribution, 27 per cent of our subjects with occlusions of peripheral arteries had this disease; in the Framingham study subjects with intermittent claudication subsequently developed coronary heart disease five times more frequently than those without claudication.\textsuperscript{28} Coronary heart disease and occlusions of peripheral arteries are found in excess in subjects with hypertension, hypercholesteremia, overweight, diabetes mellitus,\textsuperscript{29} and, in cigarette smokers,\textsuperscript{30,31} observations suggesting a similar pathogenesis of both coronary heart disease and occlusions of peripheral arteries.

Detection of Occlusions of Peripheral Arteries

Coronary and intracranial arteries are rather inaccessible, so that narrowing or occlusion is generally not detected before the occurrence of overt ischemic phenomena. On the contrary in the peripheral arteries—easily accessible to auscultation, palpation, and pulse recording—narrowing and occlusions...
can often be detected, long before ischemic phenomena occur, by any interested physician using uncomplicated office procedures.\textsuperscript{39, 42} Once the diagnosis is made, more complex methods of evaluation (blood flow measurement, arteriography) not yet currently available for coronary arteries, may help to estimate the extent and the precise localization of the disease for therapeutic and research purposes.

**Discussion**

This study in Basle indicates that occlusion of peripheral arteries is a frequent manifestation of atherosclerosis even in relatively young working persons. In the general population occlusions are probably still more prevalent than in the population studied: subjects incapacitated by occlusions of peripheral arteries did not participate, since the study was limited to working people; most of the volunteers had been subjected by industrial physicians to biennial health examinations, so that some cases of disease were probably excluded from this survey; the screening tests, even though relatively sensitive, may nevertheless have overlooked some narrowing of arteries detectable by more sensitive methods (auscultation, arteriography).

The comparison of hospitalized and working groups demonstrates in a striking manner how greatly the findings vary according to the population investigated. Predominance of men, lower limb occlusions, bilateral occlusions, and concomitant coronary heart disease are much more frequent in hospitalized than in working subjects. Some of the actually existing disagreement concerning the age distribution, sex ratio, and frequency of complaints, among others, may result because different investigators draw their conclusions from different population groups, often poorly described and defined.

Coronary heart disease and occlusions of peripheral arteries share many epidemiologic features, and subjects with each of these diseases often have similar characteristics. Consequently, an examination of the accessible peripheral arteries may often allow the detection of atherosclerosis years before symptomatic manifestations, hopefully early enough to start preventive measures that may spare the patient the major, frequently irreversible and lethal complications of myocardial infarction, cerebral vascular accidents, and gangrene.

**Summary**

A group of 6,400 volunteers aged 15 to 64 employed in the pharmaceutical industry in Basle, Switzerland, were examined for occlusions of limb arteries. Each subject was given a screening examination including a cardiovascular history, palpation, and electronic recording of foot and wrist pulses. An additional, more detailed examination was done on 294 subjects with pathologic or doubtful screening findings. This included arteriography for 83 subjects.

Occlusions of peripheral arteries were found in 99 extremities of 75 subjects. One sixth was located in arteries of the upper extremities; 14 per cent concerned the iliac, 49 per cent the femoral arteries, and 23 per cent the arteries of the lower leg. In the age group 15 to 39 years occlusions occurred as frequently in women as in men, while a male predominance of 1.6:1 was noted in the 40 to 64 age group. The prevalence rose progressively from 0.1 per cent below age 40 to 8 per cent in the 60 to 64-year-old men. Occlusions were not infrequent in young men; 1 per cent was noted in the age group 40 to 44.

The history was not found reliable for detection of peripheral arterial occlusions. About two of three subjects with demonstrated occlusions failed to exhibit classical symptoms of reduced blood flow in skin or muscle. Conversely, approximately one of four men and one of three women with patent arteries complained of some discomfort in the legs suggestive of occlusions of peripheral arteries.

Evidence of general arterial disease was already present in many subjects with peripheral arterial occlusions: 41 per cent had an occlusion in more than one extremity, 27 per cent presented symptoms of coronary heart
disease, and 90 per cent had arteriographic evidence of atherosclerosis in nonoccluded arteries of pelvis and extremities.

A similar sex ratio, age distribution, and the frequent concurrence of occlusions of peripheral arteries and coronary heart disease in the same subject strongly suggest a common process responsible for both diseases.

A thorough examination of the readily accessible peripheral arteries by methods within the reach of most physicians may lead to the early detection of asymptomatic atherosclerotic disease, permitting the institution of preventive or therapeutic measures before the appearance of myocardial infarction, gangrene, or cerebral vascular accidents.

References
1. Ejrup, B.: Personal communication.

28. **Kannel, B.:** Personal communication.

29. **Marx, H.:** Ueber die diabetische Stoffwechsellage bei arteriellen Verschlusskrankheiten. To be published.


---

**Cases Illustrative of Appearances in Diseases Terminating in Dropsical Effusion**

*Case I.* John King, aet. 34, was admitted October 12, 1825, into the Clinical ward of Guy's Hospital, under my care. He had been a sailor till within the last four years, and was accustomed to take considerable quantities of spirits. . . . He was pale, and of an unhealthy appearance.

About three weeks before admission he was seized with pain in his loins, knees, and ankles;—his legs soon became much swollen, and his hands and face occasionally oedematous. When admitted, the abdomen was painful on pressure. Pulse 78, rather hard; tongue natural, but pale. . . . Urine scanty, about one pint in twenty-four hours. Appetite good. . . .

Urine scanty, but clear and of a natural colour. Great tenderness in the upper part of abdomen, which, he says, came on since the morning. On percussion the right side of the chest is more sonorous than the left, which is rather dull. By assistance of the stethoscope I thought the sound of the heart's beat was as if performed through fluid. . . .

He died a few hours after the visit.

**Sectio Cadaveris.—Nov. 30th.**

In this case we have a very well marked example of a granulated condition of the kidneys, connected with the secretion of coagulable urine. If we can form any judgement of the priority of disease from the more advanced state of organic change, we shall be inclined to consider that the disease in the kidney was first established, and had probably laid the foundation for that effusion into the cellular membrane which had taken place previously to his admission. . . .

The organization of the liver and its functions, as far as any means of judging could be afforded by inspection after death or observation during the progress of the disease, remained unimpaired to the very last; and the morbid appearances of the heart were of a nature to evince recent inflammatory action on the pericardium, and not that state of disease which has commonly been observed in connexion with general dropsical effusion. . . .

The dingy colour occasionally communicated to the urine in this case by admixture of blood, serves further to connect it with the other cases of dropsy with diseased kidney which I have seen.—*Original Papers of Richard Bright on Renal Disease.* Edited by A. Arnold Osman. London, Oxford University Press, 1937, pp. 5-10.
Occlusion of Peripheral Arteries: A Study of 6,400 Working Subjects
L. K. WIDMER, A. GREENSHER and W. B. KANEEL

*Circulation*. 1964;30:836-842
doi: 10.1161/01.CIR.30.6.836
*Circulation* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1964 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/30/6/836.citation

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Circulation* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to *Circulation* is online at:
http://circ.ahajournals.org//subscriptions/