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Predictive value of auscultation of femoropopliteal arteries

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Summary

BACKGROUND: Femoropopliteal bruits indicate flow turbulences and increased blood flow velocity, usually caused by an atherosclerotic plaque or stenosis. No data exist on the quality of bruits as a means for quantifying the degree of stenosis. We therefore conducted a prospective observational study to investigate the sensitivity and specificity of femoropopliteal auscultation, differentiated on the basis of bruit quality, to detect and quantify clinically relevant stenoses in patients with symptomatic and asymptomatic peripheral arterial disease (PAD).

METHODS: Patients with known chronic and stable PAD were recruited in the outpatient clinic. We included patients with known PAD and an ankle-brachial index (ABI) <0.90 and/or an ABI ≥0.90 with a history of lower limb revascularisation. Auscultation was performed independently by three investigators with varied clinical experience after a 10-minute period of rest. Femoropopliteal lesions were classified as follows: normal vessel wall or slight wall thickening (<20%), atherosclerotic plaque with below 50% reduction of the vessel lumen, prestenotic/intrastenotic ratio over 2.5 (<70%), over 3.5 (<99%) and complete occlusion (100%).

RESULTS: Weighted Cohen's κ coefficients for differentiated auscultation were low in all vascular regions and did not differ between investigators. Sensitivity was low in most areas with an increase after exercise. The highest sensitivity in detecting relevant (>50%) stenosis was found in the common femoral artery (86%).

CONCLUSION: Vascular auscultation is known to be of great use in routine clinical practice in recognising arterial abnormalities. Diagnosis of PAD is based on various diagnostic tools (pulse palpation, ABI measurement) and auscultation can localise relevant stenosis. However, auscultation alone is of limited sensitivity and specificity in grading stenosis in femoropopliteal arteries. Where PAD is clinically suspected further diagnostic tools, especially colour-coded duplex ultrasound, should be employed to quantify the underlying lesion.

Key words: *peripheral arterial disease; auscultation; duplex sonography*

Introduction

Lower extremity peripheral arterial disease (PAD) is a common manifestation of generalised atherosclerosis and is associated with a significant increase in morbidity and mortality [1, 2]. Established risk factors for PAD are advanced age, smoking, diabetes mellitus, arterial hypertension and family history. PAD can be diagnosed noninvasively by means that include the patient's history (intermittent claudication, rest pain), clinical examination (pulse abnormalities, bruits) and measuring ankle-brachial index (ABI) using a Doppler probe [3].

Femoropopliteal bruits point to flow turbulences and increased blood flow velocity, usually caused by atherosclerotic plaque or stenosis. In asymptomatic and symptomatic patients the presence of an iliac, femoral or popliteal bruit increases the likelihood of PAD [4]. However, the sole presence of a femoral bruit has a low sensitivity of 20%, but a high specificity in the clinical evaluation of PAD [5]. Peripheral auscultation after exercise may be helpful in detecting a milder arterial lesion, but may also increase the number of detected bruits without relevant underlying stenosis [6].

No data exist concerning the quality of bruits (low vs high frequency tone) to quantify the degree of stenosis. Furthermore, no studies are available regarding the experience of the investigator (e.g. medical student vs senior physician), which may influence the sensitivity and specificity of femoropopliteal auscultation in PAD.

We therefore conducted a prospective observational study into the sensitivity and specificity of femoropopliteal auscultation differentiated on the basis of bruit quality, to detect and quantify clinically relevant stenoses in patients with symptomatic and asymptomatic PAD.

Methods

Patients

Patients with known chronic and stable PAD were recruited in the outpatient clinic between September 2010 and March 2011. We included patients with known PAD with an ABI <0.90 and/or an ABI ≥0.90 with a history of lower limb revascularisation [7]. Consecutive unselected patients (age

>18 years) who were referred for a follow-up examination were asked to participate in the prospective observational cohort study. Emergency patients with acute or critical ischaemia (Rutherford classification IV–VI) were not included to avoid the time delay caused by the additional tests.

All participants were examined in accordance with a standardised protocol, including medical history, physical examination, ABI measurement and imaging by means of femoropopliteal duplex ultrasound.

Auscultation

Auscultation was performed independently by three investigators with varied clinical experience (medical student, junior physician, senior physician) after a 10-minute rest period. Five predefined locations on both legs were auscultated: the common femoral artery, superficial femoral artery (proximal, middle part and distal), and the popliteal artery. Bruits were classified subjectively as "low", "middle" and "high frequency" bruits by each investigator and were assessed at rest and after exercise (flexion-extension of the ankle) [6, 8]. The investigators were blinded for patients' history, ABI, and the others' findings. Details of the auscultation (e.g. small/large auricle, pressure on the skin) were left to the discretion of the investigator.

Colour coded duplex ultrasound

Colour-coded duplex ultrasound (CCDU) was used as the gold standard for comparison with auscultation. Imaging with a high-end duplex ultrasound machine (Logiq E9, GE Medical Systems AG, Glattbrugg, Switzerland) with a linear transducer (L 9 MHz) was performed by an experienced vascular physician blinded for the clinical data. Complete standardised imaging of the femoropopliteal arteries on both sides was performed using B-Mode and colour-coded duplex ultrasound with Doppler spectral analysis in all sections. Femoropopliteal lesions were classified as follows: normal vessel wall or slight wall thickening (<20%), atherosclerotic plaque with reduction of the vessel lumen below 50%, prestenotic/intrastenotic ratio over 2.5 (<70%), more than 3.5 (<99%) and complete occlusion (100%) [9, 10].

Each subject gave written informed consent. The study was approved by the local ethics committee (KEK-ZH-NR: 2010-0331/0).

Statistics

We calculated absolute and relative frequency for nominal variables. For comparisons between each investigator and the gold-standard duplex ultrasound, we computed weighted Cohen's κ coefficients with absolute weights. A κ value >0.75 can be considered excellent agreement, and values of κ between 0.4 and 0.75 as fair to good agreement. All confidence intervals were computed using a confidence level of 95%. Sensitivity and specificity were calculated using the following formulas: sensitivity = true positive / (true positive + false negative) and specificity = true negative / (true negative + false positive). True positive and true negative results, as well as sensitivity and specificity at rest and after exercise, were calculated for three hypothetical situations: (1.) no bruit correlates with no stenosis on CCDU; (2.) any bruit with a stenosis >50% on CCDU; (3.) no bruit with complete occlusion on CCDU as the reference test.

Table 1: Patients' characteristics (n = 98).

Age, years (range)	71.3 ± 11.3 (42–92)
Male, n (%)	61 (62.2)
BMI, kg/m^2 (range)	26.6 ± 4.7 (18.1–40.4)
Smoking, n (%)	82 (83.7)
Diabetes mellitus, n (%)	37 (37.8)
Arterial hypertension, n (%)	88 (89.8)
Hypercholesterolaemia, n (%)	57 (58.2)
Family history, n (%)	30 (30.6)
Fontaine classification	
Class I, n (%)	60 (61.2)
Class II a, n (%)	24 (24.5)
Class II b, n (%)	14 (14.3)
ABI right leg* (range)	0.84 ± 0.22 (0.37–1.30)
ABI left leg* (range)	0.82 ± 0.24 (0.33–1.30)

Values are given as mean ± SD (range); nominal values in numbers (%).
* Incompressible crural arteries (ABI >1.30) in 10/98 (right leg) and 11/98 (left leg).
BMI = body mass index; ABI = ankle brachial index.

Table 2: Range of Cohen's κ coefficients for differentiated auscultation by different raters before and after exercise (no bruit: <20% stenosis or occlusion; low frequency bruit: <50% stenosis; middle frequency bruit: 50–70% stenosis; high frequency bruit: 71–99% stenosis).

	κ * at rest	κ * after exercise
Common femoral artery	0.14–0.21	0.15–0.16
Proximal superficial femoral artery	0.15–0.27	0.19–0.22
Middle superficial femoral artery	0.14–0.22	0.19–0.24
Distal superficial femoral artery	0.04–0.11	0.19–0.34
Popliteal artery	0.00–0.12	–0.04–0.07

* Range of κ coefficients from the different raters

Results

The mean age of the 98 consecutively enrolled patients was 71.3 years (range 42–92 years), and two-thirds were males. The patients' characteristics are shown in table 1.

CCDU in the 980 vascular regions showed a normal vessel lumen (<20%) in 648 (66.1%), below 50% stenosis in 222 (22.7%), 50%–70% stenosis in 26 (2.7%), high-grade stenosis (71%–99%) in 17 (1.2%) and total occlusion in 72 arteries (7.3%).

Weighted Cohen's κ coefficients for differentiated auscultation were low in all vascular regions and between all the different investigators (table 2). Table 3 shows the true positive and true negative results of femoropopliteal auscultation in different vascular regions (range of different raters). Ranges of sensitivity and specificity of femoropopliteal auscultation by the different raters in the individual vascular regions are shown in table 4. Sensitivity was low in most areas, with an increase after exercise. The highest sensitivity in detecting relevant (>50%) stenosis was found in the common femoral artery (86%). Specificity was high at rest with a slight decrease after exercise. Table 5 shows the incidence of bruits in the three different vascular regions for investigator 1 compared with duplex findings (significant vs nonsignificant stenosis).

Table 3: True positive and true negative results of femoropopliteal auscultation in different vascular regions (range from the different raters).

	True positive at rest (%)	True negative at rest (%)	True positive after exercise (%)	True negative after exercise (%)
Duplex: <20% stenosis Auscultation: no bruit				
Common femoral artery	51.3–56.5	10.9–15.5	32.1–37.3	20.2–24.4
Proximal superficial femoral artery	52.0–53.7	10.7–17.2	41.8–43.1	24.9–27.1
Middle superficial femoral artery	58.2–62.5	5.4–10.3	50.0–53.3	15.8–18.5
Distal superficial femoral artery	69.8–70.4	1.1–2.9	65.5–69.3	5.2–9.5
Popliteal artery	80.1–82.2	0.5–0.5	77.5–79.1	0.5–2.2
Duplex: >50% stenosis Auscultation: any bruit				
Common femoral artery	3.1–3.1	60.2–70.9	3.6–3.6	33.7–42.9
Proximal superficial femoral artery	1.0–2.0	71.9–78.6	2.6–2.6	54.1–56.6
Middle superficial femoral artery	1.5–2.0	78.1–88.8	1.5–2.0	64.3–68.9
Distal superficial femoral artery	0.5–1.5	88.8–93.4	2.0–3.1	83.7–89.8
Popliteal artery	0.0–0.5	91.8–97.4	2.6–2.6	54.1–56.6
Duplex: occlusion Auscultation: no bruit				
Common femoral artery	1.0–1.5	28.1–37.2	0.5–0.5	56.1–65.3
Proximal superficial femoral artery	7.1–9.2	18.4–22.4	5.1–7.7	38.8–41.8
Middle superficial femoral artery	11.7–13.8	8.2–15.8	10.7–12.2	24.5–30.1
Distal superficial femoral artery	8.2–8.7	1.0–3.6	8.2–8.7	6.1–12.2
Popliteal artery	2.0–2.6	1.0–3.1	2.0–2.6	4.6–6.1

Table 4: Sensitivity and specificity of femoropopliteal auscultation in different vascular regions (range from the different raters).

	Sensitivity at rest (%)	Specificity at rest (%)	Sensitivity after exercise (%)	Specificity after exercise (%)
Duplex: <20% stenosis Auscultation: no bruit				
Common femoral artery	42–60	69–76	78–94	43–50
Proximal superficial femoral artery	28–45	84–87	65–71	68–70
Middle superficial femoral artery	16–31	87–94	47–55	75–80
Distal superficial femoral artery	4–10	98–100	18–32	92–98
Popliteal artery	3	97–99	3–12	94–96
Duplex: >50% stenosis Auscultation: any bruit				
Common femoral artery	86	64–74	100	35–44
Proximal superficial femoral artery	29–57	77–81	71	56–59
Middle superficial femoral artery	38–50	84–93	38–50	67–74
Distal superficial femoral artery	8–25	98–99	33–50	89–96
Popliteal artery	0–25	97–99	0–25	94–96
Duplex: occlusion Auscultation: no bruit				
Common femoral artery	0–33	62–72	67	34–43
Proximal superficial femoral artery	5–12	75–80	21–38	54–56
Middle superficial femoral artery	4–8	81–90	12–25	65–71
Distal superficial femoral artery	0	96–99	0–6	87–93
Popliteal artery	0	97–99	0	94–95

Discussion

This is the first clinical study to investigate the clinical value of auscultation alone, differentiated according to the perceived frequency tone of the bruit, in diagnosing femoropopliteal stenoses and occlusions in patients with PAD.

Clinical experience suggests that a high-frequency bruit may be induced by a high-grade stenosis, whereas the absence of a bruit indicates an occluded or normal vessel. To date no data exist concerning the quality of bruits in quantifying degree of stenosis.

The most disappointing result of our blinded study was the low κ coefficients for all investigators in all arterial regions (table 2). Even provocation manoeuvres with lower extremity exercise did not result in sufficient agreement of clinical examination and duplex ultrasound (κ coefficients <0.3). Thus auscultation alone is not reliable for quantification of femoropopliteal stenoses or occlusions.

Auscultation, however, remains a helpful tool in distinguishing between a normal vessel, relevant stenosis and occlusion (table 3). Relatively low sensitivity in detecting >50% stenoses improved after physical exercise. Specificity at rest for detection of normal, stenosed or occluded arteries was acceptably high at >90% in most vascular areas. These findings are in agreement with the literature, which showed quite low sensitivity of a femoral bruit of 20% but high specificity of 96% in the evaluation of PAD [5]. In another study, bruits at rest were found only in 63% of patients with arterial obstruction and in 7% of controls [6].

The value of auscultation in other vascular regions is also limited. Cervical bruits alone were not predictive of high-grade (>70%) symptomatic carotid stenosis with low sensitivity (63%) and specificity (61%) compared with angiography in the North American Symptomatic Carotid Endarterectomy Trial (NASCET) [11]. Another study in asymptomatic patients with a prevalence of haemodynamically significant stenosis of >60% as detected by ultrasound, showed sensitivity of 56% with a high specificity of 98% [12]. However, inter-rater agreement rates are known to be high, at 96% for carotid and 97% for femoral auscultation [13]. Also, abdominal bruits are known to be relatively nonspecific and may be absent in 60% of patients with stenoses or occlusions of renal arteries, but may be present in patients with normal mesenteric and renal arteries [14].

Vascular auscultation has its strengths in specific indications. High-frequency bruits are reliable in detecting arteriovenous fistulas or renal artery stenosis after renal transplantation [15]. In routine clinical practice, the new onset of a bruit after percutaneous intervention strongly suggests the presence of a femoral artery false aneurysm or arteriovenous fistula, and further imaging is mandatory [16].

Auscultation may be limited in very obese, agitated or anxious patients. False positive murmurs may be caused by collateral vessels in the area of an occluded artery, a pronounced elongation or kink of an artery, severe arterial hypertension or other vascular abnormalities.

Patient selection affects the value of a diagnostic instrument. In the present study a patient population with symptomatic and asymptomatic PAD was investigated. Cardiovascular risk factors were frequent, mean ABI was significantly reduced, and CCDU revealed a vascular pathology in one third of the 648 arterial regions. These findings represent the typical situation of patients at high cardiovascular risk and with suspected PAD, and can be conferred to the daily clinical routine.

Conclusion

Vascular auscultation is known to play a highly useful role in clinical routine as a means of recognising arterial abnormalities. Diagnosis of PAD is based on different diagnostic tools (pulse palpation, ABI measurement), and auscultation can localise relevant stenosis. However, auscultation alone is of limited sensitivity and specificity in grading stenosis in the femoropopliteal arteries. If PAD is suspected clinically, further diagnostic tools, especially colour-coded duplex ultrasound, should be employed to quantify the underlying lesion.

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Table 5: Auscultation and duplex findings in different vascular regions: incidence of bruits in the three different vascular regions for investigator 1 compared with duplex findings (significant vs nonsignificant stenosis).

	Common femoral artery	Superficial femoral artery	Popliteal artery
Duplex: >50% stenosis			
No bruit (n/total)	1/196	21/588	3/196
Any bruit (n/total)	6/196	6/588	1/196
Duplex:<50% stenosis			
No bruit (n/total)	139/196	489/588	186/196
Any bruit (n/total)	49/196	48/588	1/196

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