PERIPHERAL BLOOD FLOW AND ITS MODIFICATION BY PERIDURAL SYMPATHETIC BLOCK*

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THIS REPORT is concerned with the variations in the blood flow to the skin and muscle of the lower extremities of adults, with and without evidence of peripheral vascular disease,¹ and the modifications effected by sympathetic block.^{2,4} This work shows that sympathetic block causes a marked increase in skin blood flow of the normal limb but not so in the limb with peripheral vascular disease. There was no significant change detected in muscle blood flow with sympathetic block.

OBJECTIVES

(a) To investigate the value of the absolute resting skin blood flow and the reactive hyperaemic flow before and after sympathetic block as a means of predicting the effect of lumbar sympathectomy in peripheral vascular disease.

(b) To investigate the effect of sympathetic block on the skin blood flow of the normal limb afflicted with acute peripheral ischaemia.³

(c) To investigate, by doing simultaneous muscle blood flow studies, the possible effect of redistribution of blood flow from the skin compartment to muscle or vice versa.²

Various methods of causing peripheral vasodilatation, including systemic agents, intra-arterial agents, and sympathetic blocks, are available. It is felt that peridural sympathetic block has the great advantage of pin-pointing vascular dilatation when compared with systemic agents.³

METHOD

The first or control group consists of thirty-one volunteer subjects who were medical students and hospital patients, all without evidence of peripheral vascular disease. In the second group there were thirty-eight patients with clinical evidence of peripheral vascular disease. Blood flow was measured by venous occlusion plethysmography of Lewis and Grant⁸ as modified by Barcroft and Edholm.⁹ It has been shown that blood flow in the foot closely resembles that of skin, while the calf is composed, to a large part, of muscle. The temperature-constant⁸⁻¹⁰ plethysmographs were accordingly fixed to the foot on one side, calf on the other. Unpremedicated subjects, not permitted to smoke or sleep, were placed in a semi-Fowler position. The blood pressure was closely observed.

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Resting and hyperaemic blood flows were established for foot and calf and then obtained again after sympathetic block. The resting blood flow was recorded three times on five separate occasions and averages were taken to establish the flow rates. Reactive hyperaemic blood flow was that flow obtained following release after two minutes of arterial occlusion by a cuff. This flow was recorded for two minutes and calculated by planimetry from the area under the curve for the first minute.

The resting blood flow was re-established at pre-existing levels before proceeding to the sympathetic block. Sympathetic block was done using lignocaine, without adrenaline, through a peridural catheter. Sympathetic block was confirmed by an anaesthetic skin band and the subjective report of the patient on increased warmth and comfort of the extremity.

RESULTS

Results are expressed in ml. of blood per 100 gm. of tissue per minute.

A. Results in Foot, Which Reflects Skin Blood Flow

The left half of Figure 1 shows the resting blood flow of the foot in patients with peripheral vascular disease to be significantly higher than in the control group, as follows:

Control group	2.09 s.d. 1.28	} ($P = 0.015$)
Peripheral vascular disease group	3.13 s.d. 1.96	

Figure 1 then compares the resting blood flow in the foot of both groups before and after peridural sympathetic block. A significant increase is observed for the controls but not for the peripheral vascular disease group. After peridural sympathetic block the resting blood flow in the foot was:

Control group	8.25 s.d. 2.20	} ($P = 0.003$)
Peripheral vascular disease group	4.02 s.d. 6.18	

For the control group the resting blood flow in the foot was significantly increased by sympathetic block:

Before peridural sympathetic block	2.09 s.d. 1.28	} ($P = 0.001$)
After peridural sympathetic block	8.25 s.d. 2.20	

The peripheral vascular disease group showed no significant increase in foot resting blood flow after sympathetic block:

Before peridural sympathetic block	3.13 s.d. 1.96	} ($P = 0.85$)
After peridural sympathetic block	4.02 s.d. 6.18	

B. Results in Calf, Which Reflects Muscle Blood Flow

The left half of Figure 2 shows the resting blood flow in the calf with no significant difference between the two groups:

Control group	1.79 s.d. 0.99	} ($P = 0.15$)
Peripheral vascular disease group	2.06 s.d. 0.90

FIGURE 1. Resting blood flow in foot, before and after sympath

Figure 2 then compares the resting blood flow in the calf of b and after peridural sympathetic block. In the peripheral vascu there is no significant increase but in the controls an increase jn fificance at the 0.05 level is observed. The values obtained after thetic block were:

Control group	2.61 s.d. 0.32.	} (P =
Peripheral vascular disease group	2.38 s.d. 0.66

FIGURE 2. Resting blood flow in calf, before and after sympathetic block.

Thus for the control group the calf resting blood flow was:

Before peridural sympathetic block 1.79 s.d. 0.99 } ($P = 0.07$)
After peridural sympathetic block 2.61 s.d. 0.32 }

While for the peripheral vascular disease group the resting blood flow was:

Before peridural sympathetic block 2.06 s.d. 0.90 } ($P = 0.65$)
After peridural sympathetic block 2.38 s.d. 0.66 }

C. Results of Reactive Hyperaemic Flow in the Foot

(Reported in ml. of blood per 100 gm. of tissue per minute after arterial

FIGURE 3. Reactive hyperaemic blood flow in foot before and after sy

occlusion for 2 minutes as described.) In the left half of Figure show a significantly higher foot reactive hyperaemic flow tha peripheral vascular disease:

Control group	29.2 s.d. 12.5	} (P
Peripheral vascular disease group	17.9 s.d. 9.11	

Figure 3 then compares the reactive hyperaemic flow ir groups before and after peridural sympathetic block. In th statistically significant increase in flow is observed after per block. The peripheral vascular disease group do not respond w flow after sympathetic block.

The reactive hyperaemic flow in the foot after peridural sympathetic block was:

Control group	40.9 s.d. 19.61	} ($P = 0.001$)
Peripheral vascular disease group	20.9 s.d. 9.07	

Thus for the control group the foot reactive hyperaemic flow was:

Before peridural sympathetic block	29.2 s.d. 12.5	} ($P = 0.025$)
After peridural sympathetic block	40.9 s.d. 19.6	

While for the peripheral vascular disease group the reactive hyperaemic flow was:

Before peridural sympathetic block	17.9 s.d. 9.1	} ($P = 0.27$)
After peridural sympathetic block	20.9 s.d. 9.0	

D. Results of Reactive Hyperaemic Flow in the Calf

The left half of Figure 4 shows the reactive hyperaemic flow in the calf to be significantly greater in the controls than in patients with peripheral vascular disease:

Control group	29.0 s.d. 11.08	} ($P = 0.05$)
Peripheral vascular disease group	22.3 s.d. 9.85	

Figure 4 then compares the reactive hyperaemic flow in the calf of both groups before and after peridural sympathetic block. No change in the blood flow pattern is observed in either group with peridural sympathetic block, the values obtained after peridural sympathetic block being:

Control group	29.6 s.d. 10.97	} ($P = 0.05$)
Peripheral vascular disease group	21.5 s.d. 8.36	

DISCUSSION

The resting blood flow to the feet of persons afflicted with peripheral vascular disease was studied. It was seen to be significantly higher than that found in normals.

Sympathetic block was effective in increasing the blood flow to normal feet but did not influence significantly the flow to the feet of patients with peripheral vascular disease either at rest or under circumstances causing hyperaemic flow.

Resting blood flow to the calf muscle of patients with peripheral vascular disease was unchanged by sympathetic block. The control group showed a moderate increase after block.

The reactive hyperaemia blood flow to the calf muscle of patients with peripheral vascular disease was unchanged by sympathetic block. Normals showed the same lack of response to sympathetic block.

There was no evidence that blood was channelled from the skin to the muscle compartment by sympathetic block.

There was nothing to suggest that chemical sympathectomy (or surgical sympathectomy) would help intermittent claudication by increasing the blood flow to ischaemic muscle.³

The blood flow to the feet of persons without evidence of peripheral vascular disease was studied. The resting blood flow was increased 4 times by sympathetic

FIGURE 4. Reactive hyperaemic blood flow in calf Before and after

block. Reactive hyperaemic flow was 14 times the resting blood flow after peridural sympathetic block. Thus such an extremity would benefit substantially from this atraumatic and readily reversible block. Peripheral ischaemia due to crushed limbs, fracture dislocation, compartment syndrome, embolization to extremity vessels, cross flaps might be thus helped.

CONCLUSIONS

1. Sufficient material has not yet been collected to be sure of the effect of peridural sympathetic block the effect of lumbar sympathectomy appears that it will be of value. At present, patients are being evaluated after this operation.

2. This work shows a significant increase in resting skin blood flow after peridural sympathetic block.

in controls, after peridural sympathetic block. Acute peripheral ischaemia would thus appear to be well treated by such a temporary chemical sympathectomy and this confirms the work of Lewis and Grant in 1925.

3. It has been established, but not accepted by all, that sympathectomy for intermittent claudication fails to increase blood flow to muscle. This is confirmed.

4. Peridural sympathetic block has been shown not to reduce skin blood flow in order to support muscle blood flow.

5. Peridural sympathetic block is a useful adjuvant in the study of peripheral blood flow.

RÉSUMÉ

Nous avons entrepris cette étude dans le but de déterminer, dans certaines conditions contrôlées, le débit sanguin dans la peau et les muscles des extrémités inférieures. Nous avons choisi, comme témoins, un groupe d'individus dépourvus de maladies vasculaires périphériques évidentes pour les comparer à des individus souffrant de telles maladies.

Buts

(a) Déterminer l'importance du débit sanguin de la peau, au repos absolu, et l'accroissement de débit réactionnel avant et après le blocage sympathique, comme moyen de prédire les effets de la sympathectomie lombaire dans les maladies vasculaires périphériques.

(b) Rechercher les effets du blocage sympathique sur le débit sanguin de la peau d'un membre normal soumis à une ischémie périphérique aiguë.

(c) Etudier, en faisant des déterminations simultanées de débits sanguins musculaires, les effets possibles de la redistribution du débit sanguin de la peau aux muscles, ou vice-versa.

Dans des conditions de température constante, nous avons employé le pléthysmographe à occlusion veineuse de Lewis et Grant, et nous l'avons fixé au mollet sur un côté et au pied sur l'autre. Nous avons démontré que le débit sanguin du pied ressemble à celui de la peau, tandis que celui du mollet ressemble à celui des muscles. Nous avons déterminé des débits sanguins sur le pied et sur le mollet, au repos et en hyperémie, et nous avons refait les déterminations après un blocage sympathique peridural des membres à l'étude.

Résultats

(a) Au repos, dans le pied, le débit sanguin chez les porteurs de maladies vasculaires périphériques est beaucoup plus considérable que chez les témoins. Chez les témoins, le blocage sympathique augmente le débit sanguin au repos, ce qu'il ne fait pas chez les porteurs de pathologie vasculaire.

(b) Dans le mollet, le débit sanguin de repos est le même dans les deux groupes. Le blocage sympathique ne produit aucun effet chez les porteurs de maladies vasculaires, mais il augmente le débit chez les témoins.

(c) Dans le pied, ce débit accru réactionnel est beaucoup plus marqué chez les témoins que chez les porteurs de pathologies. Le blocage sympathique, avant l'occlusion artérielle, augmente de façon importante le débit sanguin chez les témoins. Chez les porteurs de maladies, nous n'avons observé aucun changement.

(d) Le débit accru réactionnel dans le mollet est beaucoup plus marqué chez les témoins. Le blocage sympathique n'a apporté aucun changement dans aucun groupe.

Conclusions

1. Nous n'avons pas accumulé assez de renseignements pour pouvoir prédire de façon certaine, par le blocage sympathique péri-dural, les effets de la sympathectomie lombaire, mais il semblerait que cette opération n'a aucune valeur. En ce moment, nous étudions des malades avant et après cette opération.

2. Cette étude a démontré qu'il existe, particulièrement chez les témoins, après un blocage sympathique péri-dural, une augmentation importante du débit sanguin cutané au repos. En conséquence, il semblerait que, dans des cas d'ischémie aigue périphérique, cette sympathectomie chimique temporaire constitue un traitement adéquat, ce qui confirme les dires de Lewis et Grant en 1925.

3. Il est établi, mais non accepté par tous, que la sympathectomie pour la claudication intermittente n'augmente pas le débit sanguin musculaire. Cela est confirmé.

4. Nous avons démontré que le blocage sympathique péri-dural ne diminue pas le débit sanguin cutané pour augmenter le débit sanguin musculaire.

5. Le blocage sympathique péri-dural s'est avéré un précieux adjuvant pour l'étude du débit sanguin périphérique.

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