

The effect of oxygen inhalation and intravenous Naftidrofuryl on the transcutaneous partial oxygen pressure in ischaemic lower limbs

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Abstract

The effect of oxygen inhalation at atmospheric pressure and Naftidrofuryl infusion (N) on the TCpO₂ is shown.

At the central control site—5 cm below the midclavicular line—oxygen inhalation produced a significant increase in TCpO₂, whereas there was no change after Naftidrofuryl infusion. At the 10 cm below-knee site, there were significant rises after oxygen inhalation alone, Naftidrofuryl alone and both combined. The study was conducted on 20 patients (23 legs).

It is suggested that this study can form the basis for a regimen to improve the viability of ischaemic limbs showing borderline TCpO₂ readings, and increase the chances of a successful below-knee amputation.

Introduction

The value of transcutaneous partial oxygen pressure (TCpO₂) recording in assessing skin viability has been the subject of recent publications (Achauer et al, 1980; Dowd et al, 1983). In a previous communication we have shown average TCpO₂ in a group of young healthy volunteers, elderly healthy volunteers, and a group of patients with lower limb ischaemia in varying degrees of severity (Mustapha et al, 1983).

Our findings relate closely to other researchers' results. A TCpO₂ recording of 40 mm Hg or over indicates adequate perfusion of the skin, and a recording below 30 mm Hg is clear indication of inadequate perfusion (Holstein et al, 1979).

In the management of the ischaemic lower limb and especially in situations where the TCpO₂ recording shows values in the borderline range of 30-40 mm Hg it is desirable to enhance the viability of the limb in general and the skin in particular, either to avoid surgery (especially amputation) or to improve the chances of success of a distal (i.e. below-knee) amputation.

This is a study of the effect of oxygen inhalation and the effect of a drug Naftidrofuryl (Praxilene LIPHA) that has been shown to enhance oxidative metabolism at cellular level (Meynaud et al, 1973).

Patients, materials and method

In this and the previous studies (Mustapha et al, 1983; Jain 1982), the TCM1 (Radiometer, Copenhagen) TCpO₂ monitor is used.

Two site readings are recorded: a control site 5 cm below the midclavicular point (either side as convenient) and a site 10 cm below the knee anteriorly. This latter site marks the critical perfusion level especially in relation to the anterior incision line of the commonly performed below-knee amputation technique.

Oxygen inhalation is administered as a 24% mixture in air (2 litre flow per minute) through a face mask or nasal spectacle. A higher flow rate was found unnecessary as it produced only marginally higher TCpO₂ recordings. Naftidrofuryl (N) is given in a dose of 400 mg six hourly mixed in 5% Dextrose in water and administered in a continuous infusion.

Oxygen inhalation was initially given to two groups of healthy volunteers: six young volunteers aged 17-25 years (average 19.5 years), and six elderly volunteers aged 54-64 years (average 59 years) with no signs of

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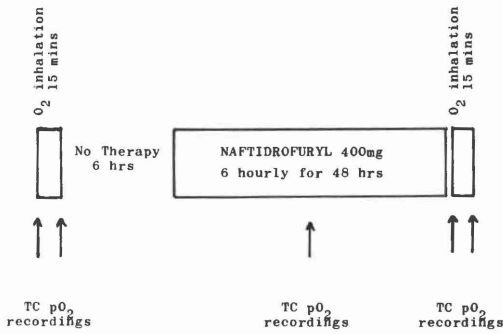


Fig. 1. TCpO₂ recordings in relation to therapy.

peripheral vascular insufficiency or central cardiopulmonary deficit.

The study was then extended to dysvascular patients, and in addition to the oxygen inhalation, the effects of Naftidrofuryl were noted according to the following regimen (Fig. 1):

A baseline TCpO₂ recording over the two sites is followed by oxygen inhalation for 15 minutes. The TCpO₂ is recorded again.

A period of six hours follows when no therapy is given, and then Naftidrofuryl 400 mg six hourly is administered for 48 hours. Soon after the end of the infusion, oxygen is administered for another period of 15 minutes. The TCpO₂ is recorded immediately before and immediately after this second oxygen inhalation.

This regimen was settled upon as the most convenient for the medical nursing staff workload as well as the clinical condition under study. It is, however, recognised that greater accuracy of assessment can be obtained if more frequent readings are taken, or the period of therapy and monitoring is extended.

Results

The group of young healthy volunteers (Table 1 and Fig. 2) showed an average TCpO₂ level of

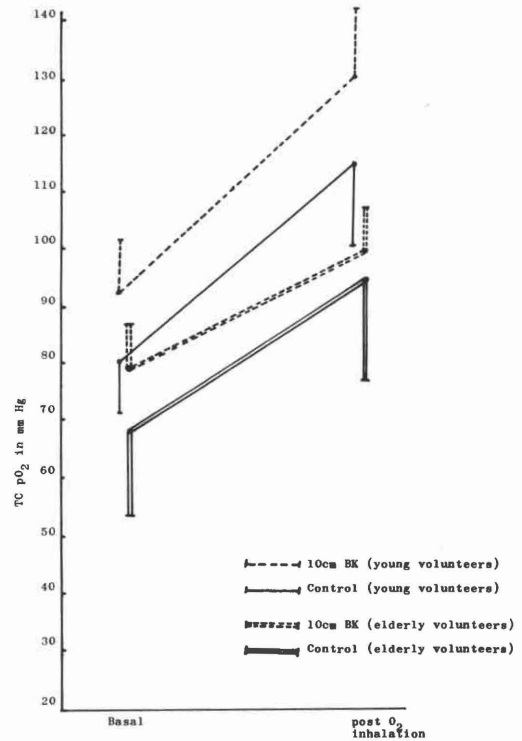


Fig. 2. Effect of oxygen inhalation on healthy volunteers.

80 mm Hg (S.D. 9.0) at the control site before oxygen inhalation, rising to 119 mm Hg (S.D. 14.1) after the 15 minutes of 24% oxygen mixture inhalation. This represents an average increase of 48% (S.D. 16.9) ($p < 0.001$). At 10 cm below the knee anteriorly, the corresponding figures were 92 mm Hg (S.D. 8.5); 129 mm Hg (S.D. 11.5) and 41% (S.D. 19.5) ($p < 0.001$).

Comparable results of TCpO₂ level in the healthy elderly group of volunteers (Table 2 and Fig. 2) were 68 mm Hg (S.D. 14.4); 94 mm Hg (S.D. 17.4); and 39.5% (S.D. 10.5) for the control site ($p < 0.001$) and 79 mm Hg (S.D. 7.6); 99 mm Hg (S.D. 7.6) and 27% rise (S.D. 11.4) for the below-knee site ($p < 0.001$).

Table 1. TCpO₂ changes in response to O₂ inhalation in 6 young volunteers. Age range 17–25 years.

| Age | Control site TCpO ₂ mm Hg | | % rise | Sign. diff. from pre O ₂ | 10 cm B/K | | % rise | Sign. diff. from pre O ₂ |
|--------------|---|-------------------------|--------|--|--------------------------|-------------------------|--------|--|
| | Before O ₂ | After O ₂ | | | Before O ₂ | After O ₂ | | |
| Average 19.5 | 80 | 119 | 48 | $p < 0.001$ | 92 | 129 | 41 | $p < 0.001$ |
| S.D. 2.9 | 9.0 | 14.1 | 16.9 | | 8.5 | 11.5 | 19.5 | |

Table 2. TCpO₂ changes in response to O₂ inhalation in 6 elderly volunteers. Age range 54-64 years.

| Age | Control site TCpO ₂ mm Hg | | | Sign. diff. from pre O ₂ | 10 cm B/K TCpO ₂ mm Hg | | | Sign. diff. from pre O ₂ |
|------------|---|-------------------------|--------|--|--------------------------------------|-------------------------|--------|--|
| | Before O ₂ | After O ₂ | % rise | | Before O ₂ | After O ₂ | % rise | |
| Average 59 | 68 | 94 | 39.5 | p<0.001 | 79 | 99 | 27 | p<0.001 |
| S.D. | 3.7 | 14.4 | 17.4 | | 10.5 | 7.6 | 7.6 | |

Table 3. TCpO₂ changes in response to O₂ inhalation and Naftidrofuryl (Praxilene)

| | TCpO ₂ Control site (n=20) | Sign. diff. from Basal | pO ₂ 10 cm B/K (n=23) | Sign. diff. from Basal | Index 10 cm B/K Control | Sign. diff. from Basal |
|--|--|------------------------------|-------------------------------------|------------------------------|-------------------------------|------------------------------|
| Basal | 62.39±15.50 | — | 42.05±14.83 | — | 0.68±0.22 | — |
| Post-Praxilene value | 60.80±14.74 | NS | 51.74±17.26 | p<0.001 | 0.86±0.26 | p<0.001 |
| Post-oxygen inhalation | 87.71±18.33 | p<0.001 | 56.77±18.49 | p<0.001 | 0.64±0.15 | NS |
| Post-Prax. and oxygen inhalation | 86.38±16.76 | p<0.001 | 64.13±19.80 | p<0.001 | 0.73±0.20 | NS |

In the group of dysvascular patients studied, 20 patients, 23 legs (Table 3 and Fig. 3) recordings over the control site showed a significant rise following oxygen inhalation from an average of 62.39 mm Hg (S.D. 15.50) to an average of 87.71 (S.D. 18.33) (p<0.001). However there was no significant difference in TCpO₂ after Praxilene infusion, rather the value reduced from 62.39 mm Hg (S.D. 15.50) to 60.80 mm Hg (S.D. 14.74).

Following Praxilene and oxygen inhalation, the TCpO₂ recorded was still higher than the baseline average, but not significantly different from the recordings following oxygen inhalation alone.

On the 10 cm below-knee site, however, there was a significant rise following oxygen inhalation alone, Praxilene alone and Praxilene plus oxygen, the figures being: 42.04 mm Hg (S.D. 14.83) baseline, and 56.77 (S.D. 18.49) following oxygen inhalation (p<0.001), 51.74 mm Hg (S.D. 17.26) following Praxilene (p<0.001), and 64.13 (S.D. 19.80) following Praxilene and oxygen inhalation (p<0.001).

Discussion

Oxygen inhalation raises the TCpO₂ throughout the body in a direct and up to a certain extent, proportionate manner, as long as there is a circulation to carry it.

The addition of Praxilene however, had no effect on the control site in the dysvascular group

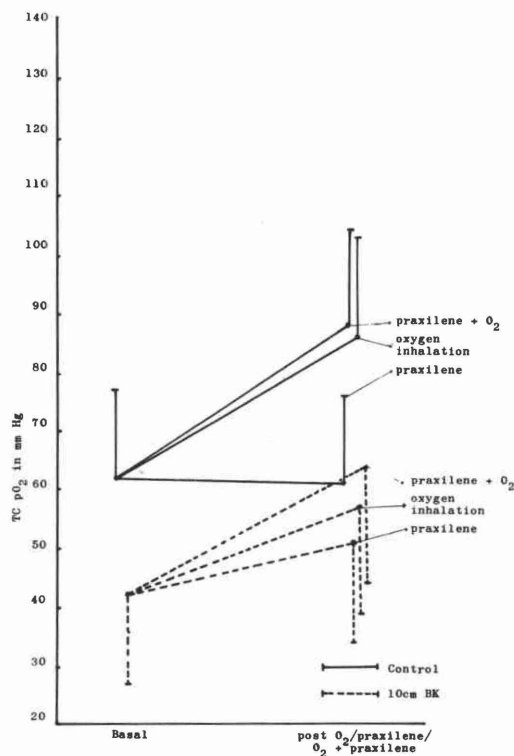


Fig. 3. TCpO₂ recordings in dysvascular patients showing the effect of O₂ inhalation and/or Praxilene.

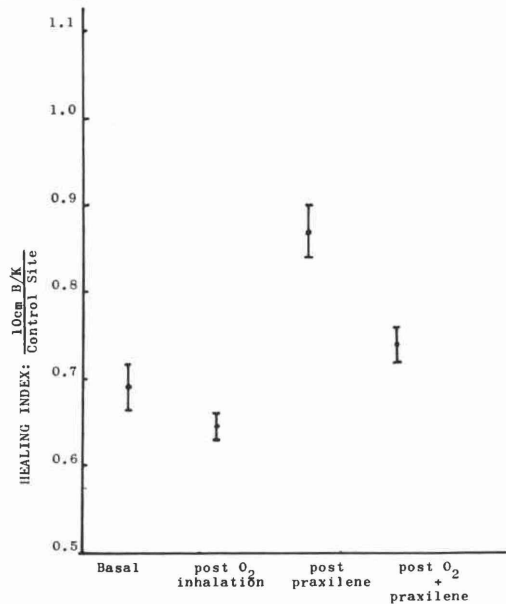


Fig. 4. TCpO₂ shown as an index $\frac{10 \text{ cm B/K}}{\text{Control site}}$: The effect of O₂ inhalation alone, Praxilene alone and both combined.

but did contribute significantly to the TCpO₂ in the ischaemic part of the lower limb. This is in keeping with a previous observation that Praxilene effects ischaemic parts selectively (Gaylarde et al, 1980; Elert et al, 1976).

This fact is reflected again in the significant difference Praxilene produces in the $\frac{10 \text{ cm B/K}}{\text{Control}}$ TCpO₂ index (Fig. 4). This idea (Healing index) (Jain, 1982) may not at this stage offer a reliable indication as to the severity of ischaemia, but its significance is under consideration and longer studies are required to establish its usefulness or otherwise.

No complications have been noted in this study from the use of oxygen inhalation or the above mentioned dosage regimen of Praxilene.

Conclusion

This study is an extension to the previous studies (Jain, 1982; Dowd et al, 1983; Mustapha et al, 1983;) in which the value of TCpO₂ was shown to be a reliable indicator of the state of perfusion in the tissues at large and the ischaemic lower limb in particular. Further studies are needed to establish whether such a regimen can assist the clinician in dealing with

borderline ischaemic conditions before or immediately following an amputation. The regimen described is presented only as a guide and varying clinical conditions will inevitably call for a flexible application. A further comparative study is contemplated to establish the regimen more firmly.

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REFERENCES

- ACHAUER, B. M., BLACK, K. S., LITKE, D. K. (1980). Transcutaneous pO₂ in flaps: a new method of survival prediction. *Plast. Reconstr. Surg.* **65**, 738-745.
- DOWD, G. S., LINGE, K., BENTLEY, G. (1983). Measurement of transcutaneous oxygen pressure in normal and ischaemic skin. *J. Bone Joint Surg.* **65-B**, 79-83.
- ELERT, C., NIEBEL, W., KARUSE, E., SATTER, P. (1976). The effect of Naftidrofuryl on energy metabolism in the musculature of limbs with impaired blood flow. *Therapiewoche.* **23**, 3947-50.
- GAYLARDE, P. M., TAN, O. T., SARKANY, I. (1980). Blood flow changes with Naftidrofuryl in systemic sclerosis and Raynaud's phenomenon *Dermatol.* **102**, 7-10.
- HOLSTEIN, P., SAGER, P., LASSEN, N. A. (1979). Wound healing in below-knee amputations in relation to the skin perfusion pressure. *Acta. Orthop. Scand.* **50**, 49-58.
- JAIN, S. K. (1982). Transcutaneous oxygen tension measurement in assessment of peripheral ischaemia in the lower limbs. Thesis for Degree of Master of Philosophy, University of Surrey, 185-186; 201-207.
- MEYNAUD, A., GRAND, M., FONTAINE, L. (1973). Effect of Naftidrofuryl upon energy metabolism of the brain. *Arzneimittelforsch.* **23**, 1431-1436.
- MUSTAPHA, N. M., REDHEAD, R. G., JAIN, S. K., WIELOGORSKI, J. W. (1983). Transcutaneous partial oxygen pressure assessment of the ischaemic lower limb. *Surg. Gynecol. Obstet.* **156**, 582-584.