

# THE VALUE OF INTERMITTENT VENOUS OCCLUSION, ITS EFFECT ON LOCAL MUSCLE CIRCULATION AS DETERMINED BY THE CLEARANCE OF RADIOACTIVE SODIUM (SODIUM 24).

E. M. McGIRR, B.Sc., M.B., Ch.B., F.R.F.P.S.G., M.R.C.P.

from The University Department of Medicine, Royal Infirmary, Glasgow.

In 1925 Lewis and Grant demonstrated by means of the plethysmograph that the release of venous tourniquets applied to the limbs of human subjects was followed by an increase in the arterial blood flow. Collens and Wilensky (1936, 1937) sought to apply the apparent increase in blood flow so produced to the treatment of peripheral vascular disease and devised an apparatus which automatically produced intermittent cycles of venous occlusion. In their experience occluding pressures of up to 80 mm. Hg. applied intermittently for periods of twelve hours daily for several weeks had a beneficial effect on the healing of ulcers, the progress of gangrene, rest pain and intermittent claudication in many cases of peripheral vascular disease. Further reports regarding the value of intermittent venous occlusion are conflicting. On the one hand it has been found to exert a beneficial influence on the course of a variety of peripheral vascular disorders (Brown & Arnott, 1937, 1938; Kramer, 1939; Evoy & de Takats, 1948; Linton, 1949); and on the other to be valueless (Allen *et al.*, 1946). Harpuder (1949) states that it does not improve intermittent claudication, rest pain, or alter the progress of tissue necrosis, but may be of value in the healing of indolent ulcers.

The immediate effects of intermittent venous occlusion on the circulation have been studied both in human beings and in animals by a multitude of experimental methods. In general it has been found that during venous occlusion the blood flow is impaired; following release of the occluding pressure a transitory increased blood flow may occur, but it does not compensate for the decreased flow during the occlusion. The long term effects of intermittent venous occlusion have not been studied experimentally.

In the present investigation the immediate effects of intermittent venous occlusion on the rate of removal of sodium 24 from the gastrocnemius muscle of human subjects have been studied. The clearance rate of the sodium has been shown by Kety (1948, 1949) to be a measure of the over all efficiency of the local circulation. Essentially the method measures the ability of the local circulation to remove, and probably to supply, freely diffusible substances. It is the only method available for the study of the local circulation in the muscle of an extremity independently of the circulatory changes in the skin and subcutaneous tissues. Accordingly it is considered to be well suited to the present study.

## METHODS.

Eleven hospital patients were investigated (Table 1). In 9 there was no evidence of vascular disease. Case 1 was a youth of 16 years with coarctation of the aorta and deficient pulsations in the lower limbs. Case 11 was an elderly diabetic with atheroma. None of the cases complained of symptoms referable to the peripheral vascular system.

Details of the technique employed have been reported elsewhere (McGirr, 1952a). Under standard conditions of rest and room temperature, 0.3 ml. of a 1 per cent solution of sodium chloride, containing not more than 10 microcuries of sodium 24, were injected into the gastrocnemius muscle. The patients were semi-recumbent. Observations were made on 12 lower limbs ; on 10 occasions the limbs were horizontal and on 2 occasions they were elevated to 45°.

TABLE 1.  
Effect of intermittent venous occlusion on the rate of removal of sodium 24 from muscle.

Case No.	Age	Sex	Diagnosis	Half-time in minutes *	
				Control	I.V.O.
1	16	M	Coarctation of aorta	10	16
2	61	F	Glossitis .. ..	13	28
3	50	M	Duodenal ulcer ..	14	20
4	38	M	Disseminated sclerosis	15	25
5	48	M	Duodenal ulcer ..	17	11
6	59	M	Haematemesis ..	18	27
7	54	M	Carcinoma ? Lung ..	19 19	19 (R) 23 (LE)
8	47	M	Neoplasm of lung ..	24	24
9	39	M	Duodenal ulcer ..	26	26
10	26	M	Psychoneurosis ..	28	28 (E)
11	79	M	Diabetes, atheroma ..	34	45

Key to abbreviations :—R = Right limb. L = Left limb. E = Limb elevated 45°.  
I.V.O. = Intermittent venous occlusion.

\* The rate of removal is expressed as the half-time.

TABLE 2.  
Summary of the effect of intermittent venous occlusion on the rate of removal of sodium 24 from muscle.

Effect on rate of removal	Number of limbs
Decreased	7
Unchanged	4
Increased	1

The gamma rays emitted by the sodium 24 were counted by means of a Geiger-Müller counter (G.E.C., type G.M. IV), placed over the site of the injection, and standard electronic counting equipment. The counting rate recorded each half-minute or minute was plotted on the ordinate of semi-logarithmic paper, and the time in half-minutes or minutes on the abscissa. In the first 5 minutes following the injection an unpredictable variation in the counting rate was recorded. After this period an exponential decrease in the counting rate occurred, and consequently a straight line graph was obtained. The slope of the graph represents the rate of removal of the sodium from the site of the injection (Kety, 1949). The rate of removal is conveniently expressed by the term 'half-time,' the time in minutes in which the counting rate is halved. Its value is easily obtained from the graph.

In each limb a control observation was made during a period of 10 to 15 minutes subsequent to the injection of the sodium. In 2 limbs the effect of venous occlusion for 2 minutes was studied during the application of the occluding pressure and for 10 minutes following its release. Thereafter in all 12 limbs the effect of intermittent venous occlusion was studied during a total period of 16 to 20 minutes, by means of a pneumatic cuff placed round the thigh and attached either to a sphygmomanometer or an intermittent venous occlusion motor. The cuff was inflated for periods of 2 minutes and then the pressure was released for periods of 2 minutes. An occluding pressure of 60 mm. Hg. was employed.

#### RESULTS.

During the application of a pressure of 60 mm. Hg. a marked impairment in the rate of removal of the sodium was found in each of the 2 limbs subjected to preliminary study. On release of the occluding pressure a transitory increase in the rate of removal, lasting about 30 seconds and above the control rate, occurred. The rate of removal then reverted to its original value (Fig. 1).

Similar results with each phase of occlusion and release occurred during intermittent venous occlusion in the 12 limbs studied. When the rate of removal during the control period was compared with the

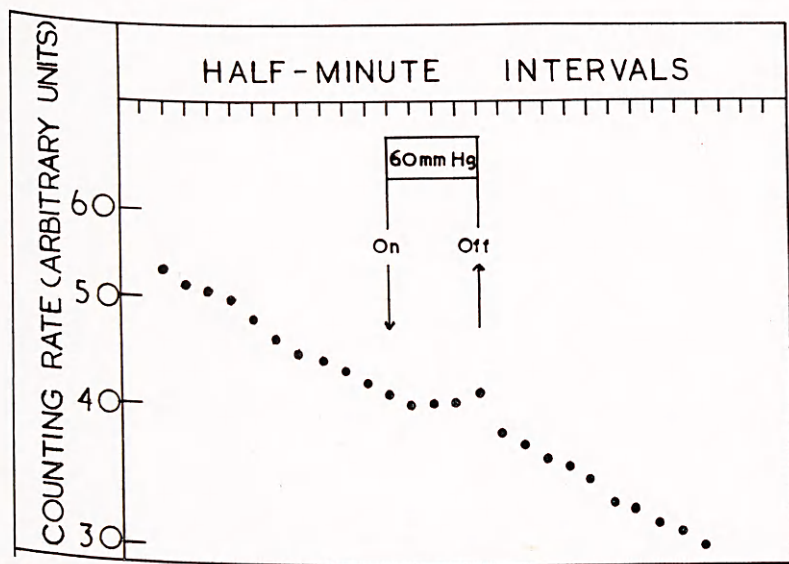


Fig. 1. Case 3. The effect of venous occlusion on the rate of removal of sodium 24 from the gastrocnemius muscle.

average rate of removal during intermittent venous occlusion it was found that the rate of removal was decreased in 7 limbs (see Fig. 2 for illustrative example), unchanged in 4 limbs, and increased in 1 limb (Tables 1 & 2).

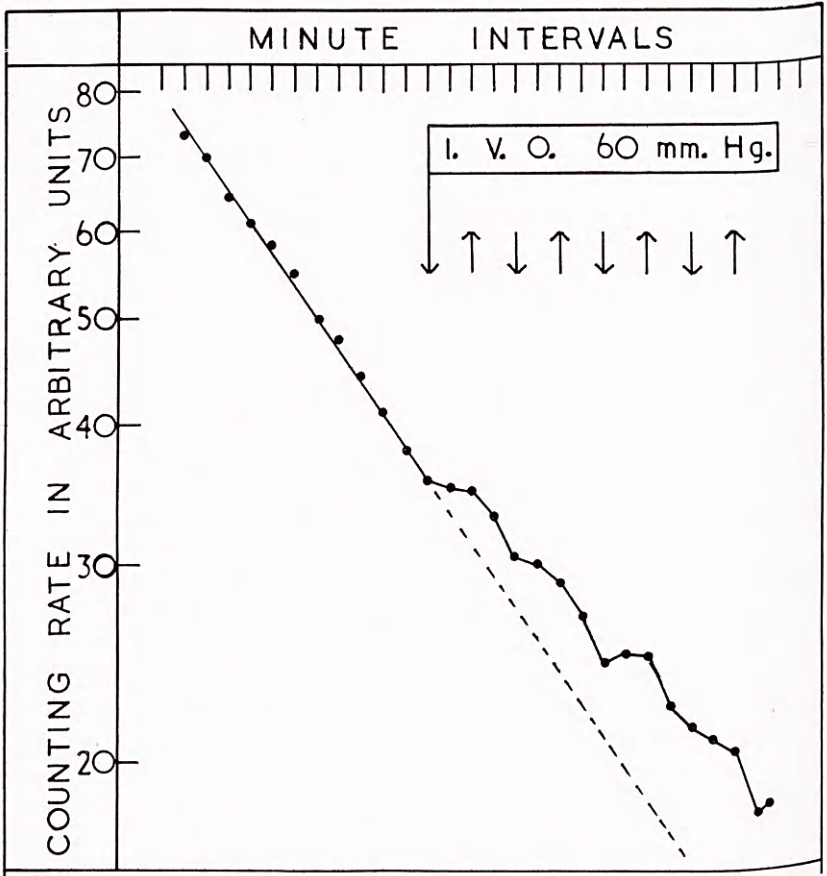


Fig. 2. Case 1. The effect of intermittent venous occlusion (I.V.O.) on the rate of removal of sodium 24 from the gastrocnemius muscle. Application and release of the occlusive pressure are indicated by the arrows.

#### DISCUSSION.

The validity of the technique as a quantitative measure of circulation depends upon the factors which influence the rate of removal of the sodium 24 from the site of injection. They have been fully discussed by Kety (1949) who concluded that the rate of removal of a tissue deposit of sodium 24 is a measure of the over all efficiency of the local circulation in its broadest sense, rather than a strict measure of blood flow. This opinion is supported by numerous other investigators whose work has

been recently reviewed by the writer (McGirr, 1952b). The method affords a direct measure of the ability of the local circulation to remove freely diffusible substances, including sodium. Kety suggests that it probably also measures the ability of the circulation to supply freely diffusible substances, including oxygen. Accordingly the method appears suitable to assess the ability of the circulation either to remove or to deal locally with the tissue metabolites which are so intimately concerned with the production of pain in intermittent claudication.

The impairment of the removal of sodium <sup>24</sup> from muscle during venous occlusion has been repeatedly demonstrated (Cooper *et al.*, 1949 ; McGirr, 1952a). It is the result of reduced local circulation. The transient increase in the removal of the sodium immediately on release of the occluding pressure is also well established (Kety, 1949 ; Cooper *et al.*, 1949 ; McGirr, 1952a). Its occurrence is due to the increased circulation of reactive hyperaemia.

The impaired rate of removal of the sodium during the application of intermittent venous occlusion in 7 of the 12 limbs studied is considered to indicate an over all reduction in the efficiency of the local circulation in the gastrocnemius muscle. In none of these limbs did the increased circulation of the reactive hyperaemic phase compensate for the impaired circulation that occurred during the occlusion. In the 4 limbs in which the removal rate was unchanged during intermittent venous occlusion it is concluded that the efficiency of the circulation was not altered. In the one limb where the removal rate was increased during intermittent venous occlusion the efficiency of the circulation was improved.

It thus appears from the results obtained in the present investigation that the local circulation of the gastrocnemius muscle of human subjects is usually either impaired or unchanged during the application of intermittent venous occlusion. The transitory hyperaemia that occurs on release of the occluding pressure very rarely overcompensates for the decreased circulation during the occlusion. No evidence is available from these studies which are concerned with the immediate effects of intermittent venous occlusion to support its value as a reliable means of improving the efficiency of the circulation of the muscle of an extremity. This conclusion is in agreement with the findings of other experimental studies in which a reliable method has been employed (Thomson & Vane, 1951). It supports the opinion that intermittent venous occlusion is unlikely to benefit cases of intermittent claudication.

#### SUMMARY.

The method of sodium clearance has been used to study the immediate effects of intermittent venous occlusion on the local muscle circulation in the lower limbs of human subjects.

During venous occlusion the circulation is impaired. Following release of the occluding pressure a transitory reactive hyperaemia occurs. The over all effect of intermittent venous occlusion is most frequently an impaired circulation.

The results obtained do not support the use of intermittent venous occlusion to improve the circulation of an extremity.

#### ACKNOWLEDGEMENTS.

I wish to acknowledge my indebtedness to the Board of Management, Royal Infirmary, Glasgow, whose financial assistance permitted this investigation to be undertaken. I am grateful to Professor L. J. Davis for his helpful criticism in the preparation of this paper.

#### REFERENCES.

- Allen, E. V., Barker, N. W. & Hines, E. A., Junr. (1946). *Peripheral Vascular Diseases*. Philadelphia & London : Saunders
- Brown, J. J. M. & Arnott, W. M. (1937). *Brit. med. J.* **1** : 1106
- Brown, J. J. M. & Arnott, W. M. (1938). *Brit. med. J.* **1** : 616
- Collens, W. S. & Wilensky, N. D. (1936). *Amer. Heart J.* **11** : 705
- Collens, W. S. & Wilensky, N. D. (1937). *J. Amer. med. Ass.* **109** : 2125
- Cooper, F. W., Elkin, D. C., Shea, P. C. & Dennis, E. W. (1949). *Surg. Gynec. Obstet.* **88** : 711
- Evoy, M. H. & de Takats, G. (1948). *Arch. intern. Med.* **81** : 292
- Harpuder, K. (1949). *Med. Clin. N. Amer.* **33** : 347
- Kety, S. S. (1948). *Amer. J. med. Sci.* **215** : 352
- Kety, S. S. (1949). *Amer. Heart J.* **38** : 321
- Kramer, D. W. (1939). *Amer. J. med. Sci.* **197** : 808
- Lewis, T. & Grant, R. (1925). *Heart.* **12** : 73
- Linton, R. R. (1949). *New Engl. J. Med.* **240** : 645
- McGirr, E. M. (1952a). *Clin. Sci.* (In press)
- McGirr, E. M. (1952b) *Brit. med. Bull.* (In press)
- Thompson, J. E. & Vane, J. R. (1951). *Lancet.* **1** : 380