Vitamin $B_{12}$ absorption in tobacco amblyopia

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It is well established that a proportion of patients with tobacco amblyopia have pernicious anaemia or some other demonstrable defect of vitamin $B_{12}$ metabolism (Leishman, 1951; Heaton, McCormick, and Freeman, 1958; Freeman and Heaton, 1961; Foulds, Chisholm, Bronté-Stewart, and Wilson, 1968). We have examined 65 cases of tobacco amblyopia diagnosed according to the criteria of Heaton and others (1958) for evidence of defective vitamin $B_{12}$ metabolism, with particular reference to vitamin $B_{12}$ absorption.

Material

All the 65 patients studied had classical tobacco amblyopia with characteristic field defects, reduced central vision, and an acquired defect of red/green colour discrimination. All but one were males, the ages ranging from 49 to 84 years (mean 66 ± 9.3), and the majority were pipe smokers (two male patients smoked cigarettes exclusively as did the one female patient in the series, one patient smoked cigars only, and five patients smoked both cigarettes and a pipe).

Estimations of serum $B_{12}$ were carried out by the Euglena gracilis assay of Ross (1952) and Schilling tests of $B_{12}$ absorption as described by Schilling (1953). The dietary intake of $B_{12}$ with estimated loss in cooking was assessed by the hospital dietician. Intestinal absorption was measured by the xylose absorption test (Helmer and Fouts, 1937).

Other investigations included full haematological examination of all patients and examination of the sternal marrow in those with anaemia (Hb < 10 g. per cent.) or with a level of $B_{12}$ in the serum of < 150 $\mu$g./ml. Where the Schilling test showed less than 12 per cent. recovery of Co$^{68}$-labelled $B_{12}$, it was repeated with added intrinsic factor.

Results

**SERUM VITAMIN $B_{12}$ LEVEL**

This was determined in 62 of the 65 patients; it was below 100 $\mu$g./ml. in nine and below 150 $\mu$g./ml. in 23 of them. It was assumed to be below 150 $\mu$g./ml. in a further three patients in whom a clinical diagnosis of pernicious anaemia was made without a determination of serum $B_{12}$ level. Taking values of 150 $\mu$g./ml. and below as abnormal, 26 of the 65 amblyopes (40 per cent.) had reduced levels. The values recorded ranged from 30 to 520 $\mu$g./ml. (mean 196 ± 119). This is significantly lower* than the mean value of 237 $\mu$g./ml. ± 119 found in a group of 72 non-amblyopic subjects, thus confirming the findings of Heaton and others (1958). The subjects in this control group were drawn from those over 45 years of age attending the Tennent Institute of Ophthalmology with conditions other than tobacco amblyopia. In age composition the groups matched,** but the control group included smokers and non-smokers.

* ($t^* = 2.02; n = 135; P = < 0.05$)
** Mean age of amblyopes 66 years ± 9.3; mean age of controls 67.3 years ± 11.8; ($t^* = 0.07; n = 135; P = > 0.1$)
DIETARY INTAKE

It was found impossible to estimate accurately the true dietary intake of vitamin B₁₂, but evidence suggesting a poor intake was obtained in 25 per cent. of the amblyopes examined.

VITAMIN B₁₂ ABSORPTION

Schilling tests were performed on 46 of the 65 amblyopes. Values of <12 per cent. recovery were found in 21 (45.7 per cent.) and of less than 5 per cent. in six (13 per cent.). Xylose absorption tests were carried out on 33 amblyopic patients and an abnormal result (i.e. < 3 g. per cent. in the urine) was found in six patients (18 per cent.) while border-line figures (3 to 4 g. per cent. in the urine) were found in a further three (9 per cent.).

VITAMIN B₁₂ IN RELATION TO TOBACCO CONSUMPTION

In an attempt to determine whether the low level of serum B₁₂ found in 40 per cent. of the tobacco amblyopes was the result of tobacco smoking or an independently determined factor, the tobacco consumption in these patients was plotted against the serum B₁₂ level (Fig. 1), when it could be seen that there was a significant though not very close positive correlation between these factors ($r = +0.384$; $n = 53$, $P = <0.01$). In this group of patients tobacco amblyopia occurred with a low consumption of tobacco, where the serum B₁₂ level was low, a much higher consumption of tobacco being the rule when the serum B₁₂ level was in the normal range. A similar trend was noted in the case of tobacco consumption and the results of the Schilling test in these patients (Fig. 2) where poor absorption of B₁₂ tended to be associated with low levels of tobacco consumption and vice versa. The correlation is less close than for serum B₁₂ ($r = +0.330$), but is significant ($n = 40$; $P = <0.05$).

![Fig. 1 Serum vitamin B₁₂ and tobacco consumption in tobacco amblyopia](image1)

![Fig. 2 Vitamin B₁₂ absorption and tobacco consumption in tobacco amblyopia](image2)

Surprisingly, a similar trend was noted when the results of the xylose absorption tests in tobacco amblyopes were compared with tobacco consumption (Fig. 3, opposite). The correlation coefficient in this instance however, was only $+0.234$, which fails to be significant ($P = >0.10$).
To test whether the relationship between tobacco consumption and serum $B_{12}$ level was common to all smokers or only amblyopes, a comparison was made between the tobacco consumption and serum $B_{12}$ level of 28 male non-amblyopic pipe smokers of similar age to the amblyopic patients (mean 64.9 years, range 43–82) (Fig. 4). No significant correlation either positive or negative was found ($r = -0.001$).

One additional comparison was made. The mean serum $B_{12}$ level in a group of non-smoking patients was compared with that of pipe-smoking non-amblyopic subjects. Both groups were drawn from a hospital population and consisted of patients in the same age range as the tobacco amblyopes who were attending hospital with eye conditions other than tobacco amblyopia. In the non-smoking group there were 43 subjects and in the pipe smoking group 28 subjects. The mean serum $B_{12}$ level in the former group was 228 $\mu$g./ml. ± 116, and in the latter 269.5 $\mu$g./ml. ± 101. There is no significant difference in the mean serum $B_{12}$ levels of the two groups ($t'' = 1.55; n = 67; P = 0.1$). The mean serum $B_{12}$ level in the pipe-smoking control group is however significantly greater than in the group of patients with tobacco amblyopia ($t'' = 2.79; n = 81; P < 0.01$). The consumption of tobacco in the group of non-amblyopic pipe smokers was not significantly different from that of the amblyopic group of patients (mean tobacco consumption of the control group 2.73 oz. per week ± 1.32 and of the amblyopic group 3.04 oz. per week ± 1.44; $t'' = 0.30; n = 81; P = 0.1$).

**Discussion**

From our results tobacco amblyopia is a condition which most readily develops in patients whose dietary $B_{12}$ or $B_{12}$ absorption is for some reason defective and in such patients amblyopia may develop even when the consumption of tobacco is only moderate ($<10$ cigarettes per day in one of our patients). Patients with normal $B_{12}$ absorption and normal levels of $B_{12}$ in the serum may also develop amblyopia if they smoke heavily enough. These facts would fit the suggestion that tobacco amblyopia is the result of a failure to detoxify cyanide derived from tobacco smoke (Wokes, 1958; Smith, 1961) and that $B_{12}$, particularly in its hydroxy form, is necessary for this detoxification (Smith, 1968).
If this is true it is not surprising that smoking patients with low serum B12 levels,
due to dietary lack or malabsorption of B12 should develop this disease, or that there should be
a direct relationship between the amount of tobacco required to induce this condition and
the amount of available B12. That patients with normal serum B12 levels should also
develop amblyopia if their tobacco consumption is high enough, might be explained as
suggested by Smith (1961) that in such patients much of the available B12 has been con-
verted to cyanocobalamin and is therefore unable to detoxify further cyanide, or that as
cyanocobalamin it is unable to support certain aspects of optic nerve metabolism.

It is known that patients with tobacco amblyopia, whether overtly B12 deficient or not,
recover vision on treatment with hydroxocobalamin ( and not cyanocobalamin) even if
smoking is continued (Chisholm, Brontë-Stewart, and Foulds, 1967), and from this alone it
is evident that in these patients, although there may be no apparent B12 deficiency, there
must be a relative deficiency of B12, or of some B12 fraction.

The development of tobacco amblyopia, however, cannot be merely the consequence of
a high cyanide intake in the presence of B12 depletion for the correlation between tobacco
intake and serum B12 levels is not very close. In addition we have examined several
patients with pernicious anaemia who are also heavy smokers and who have shown no
apparent disturbance of visual function. If B12 deficiency and heavy tobacco con-
sumption were the sole factors in the production of amblyopia, such patients would
inevitably develop the condition.

It has been suggested that tobacco consumption itself may depress B12 absorption, Leishman (1951) suggesting that swallowed products of pipe smoking might inhibit
intestinal absorption while more recently Phillips and Ainley (1968) have claimed that tobacco
smoking depresses B12 absorption as shown by the Schilling test. Our results do not
support these views. We have found no difference in the serum B12 levels of smoking
and non-smoking subjects and no correlation could be demonstrated between tobacco
intake and serum B12 level in healthy pipe smokers. In amblyopic patients on the contrary,
both B12 absorption and serum levels varied directly with tobacco consumption, the reverse
of what would be expected had tobacco intake been a significant factor in depressing B12
absorption. From our results it would appear that a depressed absorption of B12 as
shown by the Schilling test or by low levels of B12 in the serum, is an independently
determined factor which is nevertheless of aetiological significance in relation to the
development of amblyopia. The trend towards a correlation between intestinal absorption,
as shown by the xylose absorption test, and tobacco consumption in patients with tobacco
amblyopia is comparable to the results of the Schilling test, the xylose absorption test in
this instance probably giving a measure of intestinal absorption of B12, particularly in
those patients whose faulty B12 absorption is not due to a specific defect such as Addisonian
pernicious anaemia.

Summary

Schilling tests of vitamin B12 absorption, xylose tests of intestinal absorption, and measure-
ments of serum vitamin B12 were carried out in a group of 65 patients suffering from
tobacco amblyopia. Serum vitamin B12 estimations were also made on a group of non-
amblyopic pipe-smoking patients and in a similar group of non-smoking patients.

40 per cent. of tobacco amblyopes showed reduced serum levels of vitamin B12 and 45
per cent. had defective vitamin B12 absorption. Serum vitamin B12 levels in tobacco
amblyopes were significantly lower than in non-amblyopic subjects.
Vitamin $B_{12}$ absorption in tobacco amblyopia

Serum vitamin $B_{12}$ levels were similar in non-amblyopic smokers and non-smokers. In tobacco amblyopia a direct relationship was found to exist between tobacco consumption on the one hand and vitamin $B_{12}$ absorption and serum vitamin $B_{12}$ level on the other, amblyopia occurring with low tobacco consumption where vitamin $B_{12}$ absorption was poor or the serum vitamin $B_{12}$ level low, a high consumption being necessary where the serum vitamin $B_{12}$ level was high.

The significance of the findings is discussed in relation to the aetiology of tobacco amblyopia.

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