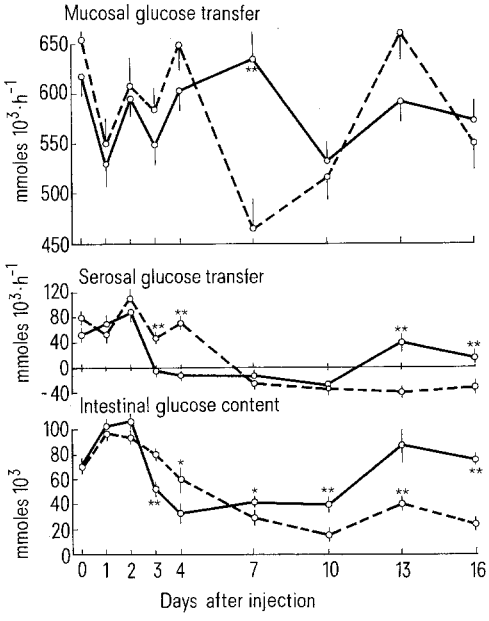
results are shown in the figure. Means were considered significantly different when $p \leqslant 0.05$.

Results and discussion. In both experimental groups the rates of serosal glucose transfer and intestinal glucose content fell significantly during infection, the fall occurring earlier after secondary than after primary infection so that by 3 days after secondary infection the parameters were significantly lower than after primary infection. A return to normal values had occurred by 13 days after secondary infection whereas the values were still significantly depressed 16 days after primary infection and were significantly lower than the secondary infection group. The rate of mucosal glucose transfer varied with time after infection but in no regular manner. Significant reductions occurred 1 day after secondary infection, which is difficult to explain, and at 7, 10 and 16 days after primary infection and 10 days after secondary infection, which corresponded to significant reductions in the other parameters measured. The difference in the variation of these parameters with time may be related to the fact that mucosal transfer rate is largely a measure of the transfer capacity of the mucosa whereas serosal transfer rate and intestinal glucose content depend on transfer rate and the rate of glucose metabolism. Intestinal glucose metabolism increases during infection[5] and leads to a greater degree of change in serosal transfer rate and intestinal glucose content than in mucosal glucose transfer.

The present work demonstrates that significant reductions in the rate of accumulation and metabolism of glucose by the small intestine and its transfer across the wall of the gut occurred sooner after secondary infection with *N. brasiliensis* than after primary infection and that these parameters returned to normal more rapidly after secondary than primary infection. The pattern of these changes is probably related to more rapid stimulation of immunological activity following secondary than primary infection[7,8], and to less pronounced and shorter lasting tissue changes in the immune than non-immune host[9].



Glucose transfer rates and content in vitro of entire small intestine of female rats at various times after primary (dotted line) or secondary infection (continuous line) with 5000 larvae of *N. brasiliensis*. n = 15 for controls (day 0), 12 for 2-day group, 9 for 1- and 3-day groups and 6 for the rest. Vertical bars are SEM. *, ** Means of the primary and secondary infections significantly different at 5% or 1% levels respectively.

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Correlation between brain blood flow and catecholamine levels in rat brain areas under hypobaric hypoxia

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Summary. Hypobaric hypoxia induces an important increase in the cerebral blood flow in all areas and more particularly in the bulb and hypothalamus; the increase in the cerebral blood flow allows for an oxygen intake sufficient to maintain the norepinephrine level in these structures.

Most effects of hypoxia on brain catecholamines have been studied under normobaric hypoxia. When the amount of inspired oxygen was reduced from 21% to 8–6%, the activities of tyrosine hydroxylase[1,2], dopamine hydroxylase and monoamine oxidase were reduced[3]. At a simulated altitude of 7.000 m[4] or 5.200 m[5], a decrease in the brain catecholamine level was observed. The decrease is related to a decrease in synthesis, since the turnover of dopamine and of norepinephrine were reduced[6]. However, in a few brain areas, the norepinephrine turnover was not changed, even at an altitude of 7.000 m[7].

These findings can be explained by 2 hypotheses; either there is variable sensitivity, according to the brain areas, of oxygen-dependent enzymes necessary for catecholamine synthesis, or a sufficient oxygen intake is ensured by changes leading to a regional blood flow redistribution. This paper deals with the verification of the latter hypothesis.

Materials and methods. All experiments were performed in Long Evans male rats weighing between 200 and 260 g. They were carried out in a decompression chamber (CRMAS) at a simulated altitude of 7.000 m corresponding to a barometric pressure of 300 Torr and to a piO_2 of 53 Torr. Decompression was performed within 5 min, the temperature being maintained at 21 ± 1 °C. The ex-

periments started 15 min after obtaining a pressure of 300 Torr.

The rats were anesthetized i.p. with chloral (360 mg/kg); various measurements were made under hypoxia: pH and pCO_2 remained practically unchanged and paO_2 equalled 33 ± 3 Torr.

The global cerebral blood flow (CBF) was measured by means of a diffusible indicator: iodoantipyrine labeled with 125 radioiodine was administered into the penis vein. 30 sec later, the animals were sacrificed with an i.v. administration of KCl. The total brain radioactivities as well as the whole body radioactivity were measured by means of spectrometry. The cerebral blood flow, expressed in ml/min/100 g was obtained by multiplying the percentage of radioactivity in the brain by the cardiac output measured by means of thermodilution.

The distribution of the CBF in the brain areas was measured by the administration of albumin microspheres. The microspheres (30 µm diameter) were injected into the carotid flow (into the left common carotid after ligation of the external carotid). The animals were killed 2 min 30 sec after the injection; the brain was rapidly removed and separated into 2 halves (left and right). Each half-brain was dissected on a cold plaque into medulla, bulb, pons, cerebellum, quadrigeminal corpus, hypothalamus, midbrain hippocampus, striatum and cortex. After homogenization in perchloric acid 0.4 N (with 0.5% EDTA and 0.5% sodium metabisulphite), the radioactivity of the centrifugation-sediment containing all the labeled iodoalbumin was determined; catecholamines were determined in the supernatant. Catecholamines were separated after adsorption on alumina[7] and determined by fluorometric method[8,9]. The results were expressed in ng/g. They represent the means derived from 6 experiments corrected for SEM.

Results and discussion. Hypobaric hypoxia induced an increase in the global flow from 40 ± 2 in animals maintained under normoxia to 72 ± 6 in animals maintained under 300 Torr for 15 min. The increase by 180% has already been reported with other methods[10,11] but it was not sufficient to assure an adquate oxygen intake to the brain (paO_2 decreases from 87 ± 4 under normoxia to 33 ± 3 Torr under hypoxia). The oxygen deficit can explain the decrease in the synthesis of catecholamines and therefore, the drop in its endogenous rate and the slowing down of the turnover in the total brain[6].

The microspheres injected into the carotid permitted the determination of the carotid flow distribution in the left brain; the right brain only received about 10% of the microspheres localized in the brain. The microsphere distribution in the left brain (table 1) was modified when the animals were exposed to 300 Torr. Particularly, the amount of microspheres increased in the lower part of the brain (medulla, bulb, pons) normally little irrigated by the carotid flow and at the level of the hypothalamus. On the contrary, in the other structures, there was a decrease in the number of microspheres and more particularly, at the level of the cortex and the quadrigeminal corpus.

The results relative to the norepinephrine levels in the cerebral structures are reported in table 2. There was a significant decrease in the quadrigeminal corpus, the midbrain, the hippocampus and especially, in the cortex, that is in brain areas in which the flow increase was slight. Similarly, the dopamine level decreased in the striatum. On the contrary, the catecholamine levels remained normal or close to normal values when the flow was sufficient, in the low parts of the brain and in the hypothalamus. A correlation was established between the percentage of the flow increase and the percentage of catecholamines as compared to the controls ($r = 0.87$). These findings demonstrate that the catecholamine levels are related to the oxygen intake. In structures in which the oxygen intake was sufficient because of a preferential flow increase, no variation in the catecholamine level was observed. The mechanism of the flow redistribution, related or not to the aminergic functioning, remains to be demonstrated.

Table 1. Distribution of cerebral blood flow in the various brain areas after an administration of iodoalbumine microspheres

Brain areas	Number of microspheres ± SEM at 760 mm Hg	Number of microspheres ± SEM at 300 mm Hg
Medulla	$11.6 \cdot 10^3 \pm 2.1$	$17.1 \cdot 10^3 \pm 6.6$**
Bulb	$15.9 \cdot 10^3 \pm 3.9$	$91.3 \cdot 10^3 \pm 33.7$**
Pons	$199 \cdot 10^3 \pm 34$	$368 \cdot 10^3 \pm 6$**
Cerebellum	$533 \cdot 10^3 \pm 47$	$686 \cdot 10^3 \pm 60$
T.quadrigeminal corpus	$760 \cdot 10^3 \pm 62$	$606 \cdot 10^3 \pm 32$**
Hypothalamus	$324 \cdot 10^3 \pm 61$	$574 \cdot 10^3 \pm 35$**
Middle brain	$545 \cdot 10^3 \pm 35$	$536 \cdot 10^3 \pm 32$
Hippocampus	$414 \cdot 10^3 \pm 26$	$374 \cdot 10^3 \pm 42$
Striatum	$578 \cdot 10^3 \pm 34$	$532 \cdot 10^3 \pm 32$
Cortex	$644 \cdot 10^3 \pm 23$	$550 \cdot 10^3 \pm 25$*

* $p < 0.05$, ** $p < 0.01$ difference between values at 760 mm Hg and 300 mm Hg (statistical significance calculated by means of the Student's t-test). Each value represents the mean value ± SEM from 10 determinations.

Table 2. Norepinephrine levels in the various brain areas and dopamine in the striatum

Brain areas	ng/g ± SEM fresh tissue at 760 mm Hg	ng/g ± SEM fresh tissue at 300 mm Hg
Medulla	809 ± 110	755 ± 133
Bulb	1176 ± 240	1220 ± 180
Pons	1516 ± 234	1560 ± 138
Cerebellum	386 ± 65	354 ± 48
T.quadrigeminal corpus	1752 ± 153	1037 ± 142**
Hypothalamus	3687 ± 549	3807 ± 238
Middle brain	1076 ± 126	864 ± 98
Hippocampus	1358 ± 200	952 ± 132*
Striatum	867 ± 81	717 ± 49
Cortex	327 ± 25	223 ± 34**
Striatum (dopamine)	5543 ± 78	4539 ± 661

* $p < 0.05$, ** $p < 0.01$ difference between values at 760 mm Hg and 300 mm Hg (statistical significance calculated by means of the Student's t-test). Each value represents the mean value ± SEM from 10 determinations.

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