Endogenous Platelet Activating Factor Does Not Modulate Blood Flow and Metabolism in Normal Rat Brain

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Both platelet activating factor and eicosanoids participate in the cerebrovascular response to ischemia. Eicosanoids also modulate cerebrovascular tone under normal physiologic circumstances, but a similar role for platelet activating factor has not been investigated. Therefore, using 16 rats, we studied the effects of the platelet activating factor receptor blockers BN 52021 (10 mg/kg, n=4 or 30 mg/kg, n=2) and WEB 2086 (5 mg/kg, n=6) on global cerebral blood flow and the cerebral metabolic rate for oxygen and compared them with the effect of indomethacin (10 mg/kg, n=4). Neither antagonist altered cerebral blood flow (112±16 and 107±14 ml/100 g/min at baseline versus 108 ±16 and 105 ±18 ml/100 g/min after BN 52021 and WEB 2086, respectively). In contrast, indomethacin significantly (p<0.05) decreased cerebral blood flow from 106±8 to 69±4 ml/100 g/min. No treatment altered the cerebral metabolic rate for oxygen compared with baseline. These data suggest that in normal rat brain, concentrations of platelet activating factor, unlike those of eicosanoids, are subthreshold and do not modulate cerebral blood flow or the cerebral metabolic rate for oxygen.

Substantial evidence supports the notion that platelet activating factor (PAF) is involved in the cerebrovascular response to ischemia.1-5 PAF (1-O-alkyl-2-acetyl-sn-glyceryl-3-phosphorylcholine) is an endogenous lipid that potently constricts blood vessels,6,7 increases microvascular permeability,8 activates granulocytes,9 and stimulates arachidonate-independent platelet aggregation.10 Intracarotid infusion of PAF in rats produces cerebral hypoperfusion and hypermetabolism, a pattern similar to that observed during reperfusion following cerebral ischemia.11,12 PAF receptor blockade attenuates the development of hypoperfusion after cerebral air embolism in rats1 and dogs3 and after carotid occlusion in gerbils.4,5 Thus, it is clear that PAF plays a role in the pathophysiologic response of the cerebral circulation and perhaps metabolism, but whether PAF plays a similar role under normal physiologic circumstances is unknown.

Some of the problems encountered in delineating the effect of PAF in the brain are related to difficulty in its isolation and quantification.13,14 In bovine brain maintained on ice for up to 4 hours after removal, Tokumura et al13 reported PAF levels as high as approximately 50 pmol/g brain (about 50 nmol/l). Clearly, one would anticipate PAF concentrations in this range to be physiologically active since several cell types are activated by PAF levels of > 1 nmol/l9 and the threshold of PAF-induced pial artery vasoconstriction is 20 nmol/l.7 However, difficulties in quantifying PAF concentrations in brain tissue have resulted in conflicting data. Recent work by Kumar et al,14 using a bioassay, indicates that PAF levels in normal rat brain may be much lower, approximately 0.25 pmol/g or about 0.25 nmol/l. This level of PAF would almost certainly be below the threshold for effects on the cerebral vasculature.7 In contrast to the difficulties in quantifying PAF concentrations, the effectiveness of certain PAF receptor blockers has been defined and these can help clarify the possible role of endogenous PAF in controlling cerebral blood flow (CBF) and cerebral metabolism. Thus, one aim of our study was to evaluate the effect of PAF receptor blockade with BN 52021 and WEB 2086 infused intravenously on CBF and the cerebral met...
abolish rate for oxygen (CMRO₂) in normal rat brain. PAF and the eicosanoids can be derived from a common precursor phospholipid 1-O-alkyl-2-arachidonoylglycerol-phosphorylcholine via phospholipase A₂. Since endogenous eicosanoids modulate both normal and postischemic CBF, our second aim was to compare the effects of PAF receptor blockade on CBF and CMRO₂ with the effect obtained with cyclooxygenase inhibition by indomethacin.

Materials and Methods

The experimental protocol was approved by the Animal Care and Use Committee of the University of Pittsburgh. Anesthesia was induced in 16 male Wistar rats weighing 300–450 g with 5% halothane in O₂. Each rat was intubated and mechanically ventilated with 1% halothane/66% N₂O/33% O₂ and immobilized with 0.1 mg/kg/hr pancuronium. Femoral arterial and venous catheters were surgically inserted. The dorsal calvaria was exposed by a midline incision, and the rat’s head was fixed in a stereotactic device (David Kopf Instruments, Tujunga, California). Rectal temperature was maintained at 38±0.2°C with a heated water blanket. An arterial blood sample was obtained to verify that blood gases, pH, and hemoglobin concentration (Hb) were within normal limits. All blood samples were replaced with an equal volume of heparinized whole blood from donor Wistar rats. Under ×20 magnification with an operating microscope and using an air dental drill, a burr hole was made over the superior sagittal sinus and a platinum microelectrode (50 μm diameter) was advanced into the sagittal sinus. After saturation with 5-6% H₂ in the inspired gas, H₂ washout was effected and CBF as milliliters per 100 g brain per minute was calculated by the Tm method as described previously. For cerebral venous blood sampling, another burr hole was made over the torcular herophili, through which a 28-gauge needle was inserted. Thereafter, 100 IU heparin (The Upjohn Co., Kalamazoo, Michigan) was administered to the rat intravenously. Cerebral venous and systemic arterial O₂ contents were determined in 0.4-ml blood samples using a cooximeter (Instrumentation Laboratories, Inc., Lexington, Massachusetts). CMRO₂ was calculated as the product of CBF and the difference (arterial minus cerebral venous) in O₂ contents.

BN 52021 (a 2 mg/ml solution of the lyophilized form in the accompanying aqueous diluent; IHB Laboratories, Le Plessis-Robinson, France) was administered intravenously at two doses. WEB 2086 (Boehringer Ingelheim, Ingelheim am Rhein, FRG) was administered as a 5 mg/ml solution in 0.1N HCl and 0.9% saline (1:20 by volume). Indomethacin (Sigma Chemical Co., St. Louis, Missouri) was prepared as a 4 mg/ml solution in distilled water with 2.5 mg NaHCO₃/ml. In pilot studies, neither the WEB 2086 vehicle containing HCl nor the indomethacin vehicle containing NaHCO₃ significantly affected CBF or CMRO₂.

After surgical preparation, each rat was allowed to stabilize for 60 minutes while being ventilated with 0.4% halothane in N₂O/O₂ (2:1 by volume). Baseline measurements of MABP, CBF, and CMRO₂ were made. The physiologic variables blood pH, PaO₂, PaCO₂, base excess, and Hb were maintained at 7.40±0.05, 125±25 torr, 35±5 torr, 0.0±5.0 mmol/l, and 13±1.5%, respectively. After baseline measurements were obtained, BN 52021 (10 mg/kg, n=4; 30 mg/kg, n=2), WEB 2086 (5 mg/kg, n=6), or indomethacin (10 mg/kg, n=4) was administered intravenously over 1 minute. MABP, CBF, and CMRO₂ were again measured in each rat 15 and 60 minutes after drug administration. Subsequently, the rats were killed with an intravenous injection of saturated KCl.

Results from the two doses of BN 52021 were combined into a single group since both doses produced a similar lack of response. All data are given as mean±SEM. Comparisons within groups were made using one-way repeated-measures analysis of variance followed by the Student-Newman-Keuls test. Comparisons among groups were made using one-way analysis of variance followed by the Student-Newman-Keuls test. The level of significance was taken as p<0.05.

Results

Controlled physiologic variables remained within the ranges previously outlined. No drug affected MABP (Table 1). Baseline CBF (Figure 1) and baseline CMRO₂ (Table 1) did not differ among the three groups. At 15 or 60 minutes after administration, neither PAF antagonist altered CBF compared with baseline (Figure 1). In contrast, indomethacin significantly decreased CBF (by 35% after 15 minutes and by 29% after 60 minutes) compared with baseline (Figure 1). Neither the PAF receptor antagonists BN 52021 and WEB 2086 nor the cyclooxygenase inhibitor indomethacin affected CMRO₂ (Table 1).

Discussion

Our finding that PAF receptor blockade with BN 52021 or WEB 2086 had no effect on CBF in normal Wistar rats is consistent with the observation of Armstead et al., who found that resting pial artery diameter in piglets was unaffected by PAF receptor blockade with U66985. The threshold concentration at which PAF causes vasoconstriction in the pial artery is approximately 20 nmol/l. Our data suggest that PAF levels in normal rat brain are less than this value, more consistent with the levels of 0.25 nmol/l reported by Kumar et al. That with that of approximately 50 nmol/l reported by Tokumura et al. We confirmed the report by Dahlgren et al. that the cyclooxygenase inhibitor indomethacin decreases CBF in normal rat brain without affecting CMRO₂. This suggests that in normal brain, PAF levels, unlike those of the eicosanoids, are less than threshold and exert no influence on global CBF.
Neither PAF receptor antagonist significantly altered normal CMRO₂ in this model; however, an increase in CMRO₂ 1 hour after WEB 2086 administration cannot be completely ruled out because of the large variability in CMRO₂ and thus the inadequate power (0.5) of the statistical analysis for WEB 2086 at this time. Previous studies in this model have demonstrated an increase in CMRO₂ during infusion of 67 pmol/min PAF. No effect of endogenous PAF on CMRO₂, however, has been described in normal or pathologic states.

The doses of BN 52021 and WEB 2086 used in this study inhibit PAF-related effects in rats, including hypotension and increased vascular permeability. Consistent with complete inhibition of any PAF effects, unpublished results from our laboratory using Bligh-Dyer extraction and vapor phase chromatography indicate that a 10 mg/kg dose of WEB 2086 in rats results in a plasma concentration of 42 ±17 fM/l after 15 minutes. This is well above the IC₅₀ value of 0.17 μmol/l reported for WEB 2086 inhibition of platelet aggregation induced by 50 nmol/l PAF. WEB 2086 is structurally similar to the benzodiazepines, but it has no anticonvulsant or sedative action.

We conclude that PAF receptor antagonism failed to alter normal global CBF and CMRO₂ in rats, suggesting that in normal brain PAF levels are subthreshold and modulate neither CBF nor CMRO₂.

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References

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