# HEAT LOAD AND SELECTIVE BRAIN COOLING IN GOATS

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## INTRODUCTION

Selective brain cooling **(SBC)** is a mechanism, by which many mammalian species can cool their brains selectively below the temperature of the arterial blood. The heat exchange resulting in **SBC** takes place between the cool venous blood of the cavernous sinus and the arterial blood passing the carotid rete for supply of the brain (1). SBC is measured as the difference between brain temperature and the temperature of the arterial blood of the carotid artery.

## METHODS & RESULTS

The experiments were performed on conscious goats at an ambient temperature of **20** °C (exceptions are marked). The animals were chronically prepared with carotid loops and an arteriovenous shunt which were connected with extracorporeal heat exchangers acting on the arterial blood to control head and trunk temperatures independently of each other (2, **3).** Guide tubes were used to measure brain and arterial blood (in the aorta and the carotid arteries) temperatures by means of thermocouples **(4).**

1. Increasing the blood temperature (+0.01 °C/min) by means of heat exchangers resulted at the beginning in a corresponding rise of brain temperature (Fig. **1).** However, at a carotid blood temperature of **38.79 ± 0.05** °C **(mean** ± standard deviation of 17 experiments in 3 goats) the threshold temperature of **SBC** was reached and brain temperature became lower than blood temperature. During **SBC** brain temperature increased at a much lower rate than blood temperature. At a blood temperature of **40.4** °C **SBC** was **1.3** °C, which means, that brain temperature was **1.3** °C lower than carotid blood temperature. **SBC** increased with arterial blood temperature (2).

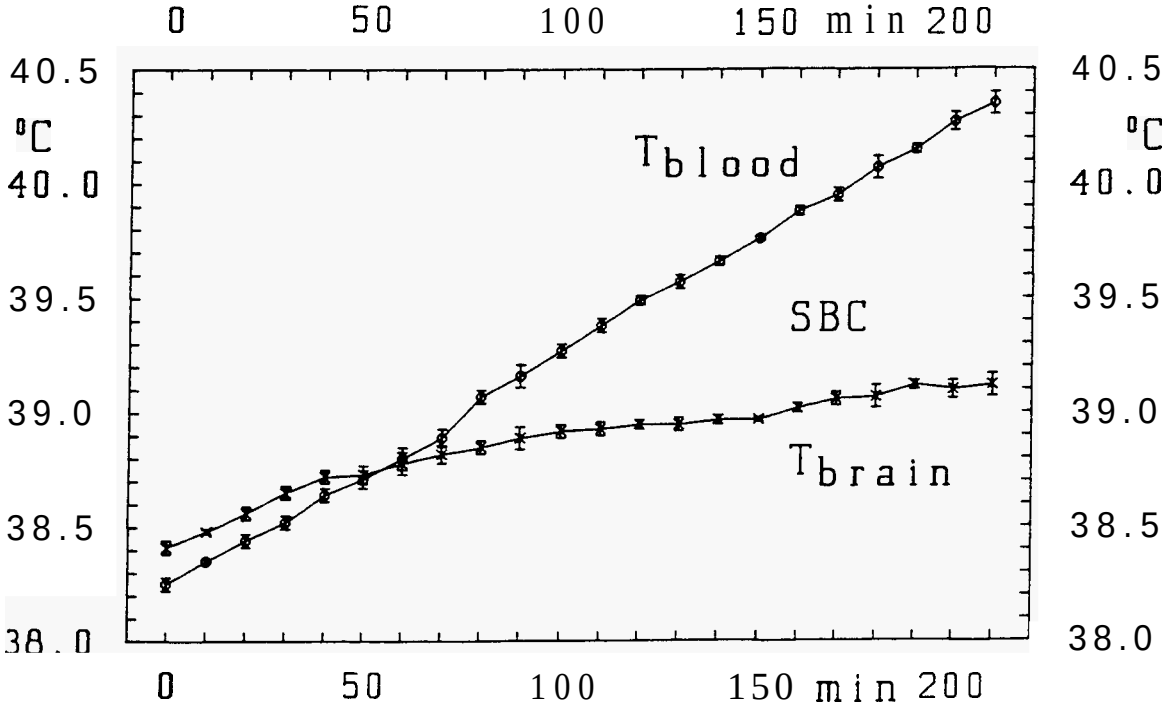


Fig. 1. Increase of arterial blood temperature (+0.01 °C/min) by means of extracorporeal heat exchangers. Means and SEMs of **17** experiments in **3** goats are plotted versus time. SBC, selective brain cooling (SBC = $T_{blood}$ minus $T_{brain}$).

2. Increasing the carotid blood temperature at low and constant trunk temperatures resulted in the activation of SBC. The specific combination of low trunk temperature and high carotid blood temperature induced SBC without a rise of respiratory evaporative heat loss. 19 experiments in 3 goats showed that the degree of SBC was principally independent of respiratory evaporative heat loss: high levels of heat loss were found without SBC, and large degrees of SBC were observed at low levels of heat loss (2).

3. The i.v. injection of lipopolysaccharide (0.5 $\mu$g/kg, *Salmonella typhosa)* induced fever (7 goats, n = 17) which was accompanied by a rise of blood temperature. In spite of high blood temperatures during fever SBC was significantly reduced by 80% compared to SBC of unfebrile animals at the same blood temperature. For instance, at a blood temperature of 40.5 °C SBC was 1.3 °C in non-febrile goats and 0.2 °C in febrile goats (4).

4. Increasing the relative humidity of the inspired air from 22% to 85% at constant air temperature of 35 °C reduced the cooling power of the inspired air and diminished SBC by approximately 50%. The reduction of SBC resulted in relatively higher brain temperatures and consequently caused a stronger activation of heat loss mechanisms. This effect of reduced SBC can partly compensate the lower cooling power of the inspired air (3).

CONCLUSIONS

The results show that SBC occurs during both hyperthermia and normothermia. SBC in goats is not a side-effect of panting although panting can support the expression of SBC by improving the potential cooling power. The threshold of SBC depends on carotid blood temperature and head temperature, respectively.

SBC has been viewed as a mechanism which can protect the brain from overheating and heat damage. However, during fever and exercise (5) when the risk of overheating is high, this protection by SBC is reduced. It becomes obvious that another effect of SBC is perhaps more important: to modify thermoregulatory responses by changing brain temperature due to SBC. SBC uncouples brain temperature from trunk temperature during hyperthermia. Therefore, *trunk* temperature becomes the main part in generating thermal signals driving heat loss mechanisms. This effect leads to a more economical activation of heat loss mechanisms because the interthreshold zone becomes wider and the increase of heat loss is smoothed (3). SBC enables the animal to adjust the thermoregulatory responses to the cooling power of the inspired air as shown by experiments with low or high humidity of the inspired air. This effect of SBC impairs the homoiothermy of the brain but supports the homoiothermy of the whole animal.

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