Overall research theme:

Integrative studies of human cardiovascular control in health and disease. Applications in clinical medicine and exercise physiology.

Latest update:

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Characteristics of the research group:

Studies aim to evaluate integrative aspects of human cardiovascular control in healthy subjects, clinical medicine and during anaesthesia. The department is characterised by an ability to perform extensive monitoring of the circulation by both invasive and non-invasive procedures. Thus, the central circulation is monitored by a pulmonary artery catheter while regional flows are monitored by catheterisation of the respective venous drainage, e.g. from the arms, legs, brain, and liver. Regional changes in volume are assessed non-invasively by electrical impedance and oxygenation of the brain and skeletal muscle by near-infrared spectroscopy (NIRS). Catheterisation permits evaluation of regional metabolism and the hormonal influence on the circulation. Assessments range from the elite athlete performing maximal exercise to critically ill patients during intensive care and major surgery. Methods for defining "normovolaemia" and evaluation of the role of the central circulation in the redistribution of cardiac output and regional blood flow are of further interest.

Running projects: Titles and abstracts:

Arterial baroreceptors and cardiovascular control in humans

The arterial baroreceptors form the classical control system for the regulation of heart rate and blood pressure. Thus, attenuation of the transmural pressure in the baroreceptor field results in an increase in heart rate and systemic vascular pressure. However, the arterial baroreceptors are "reset" to control the altered prevailing blood pressure of different physiological and pathophysiological conditions, e.g. the elevated blood pressure and heart rate during exercise. We have demonstrated that influence from both the central nervous system and the exercising muscles contribute to such resetting. Equally, the baroreceptors are reset by changes in the central blood volume and indirectly, the function of the aortic baroreceptors is also evaluated. Studies are directed to evaluate the role of the arterial baroreceptors in cardiovascular regulation in situations associated with hypotension.

Cardiovascular control during hypovolaemic shock

Cardiovascular responses during hypovolaemic shock are associated with an increase in heart rate and total peripheral resistance. However, three separate phases can be described. Initially, blood pressure and heart rate increase in response to enhanced sympathetic activity and concomitant increase in peripheral resistance. With a blood loss of approximately 30%, heart rate and blood pressure decrease in response to an increase in vagal tone and loss of sympathetic tone. Only with a larger blood loss, hypotension is associated with an increase in heart rate. Evaluations aim to develop and validate central blood volume monitoring methods and to describe the prevalence of the "physiologic" response in different types of patient populations.

Regulation of muscle blood flow during exercise

When muscle contracts local vasodilatation secures an increase in perfusion. However, during whole body exercise the increase in muscle blood flow is smaller than when a given muscle group is working alone. Manipulation of the associated vasodilatation by varying the engaged muscle mass suggests that

blood pressure is the primarily regulated variable and that changes in muscle blood flow, including working skeletal muscles, are secondary to blood pressure homeostasis. The aim of these studies is to evaluate the effect of central blood volume manipulations on cardiac output and its redistribution during exercise.

Brain metabolism and oxygenation

The circulation is often considered to prioritise perfusion of the brain and the heart. However, hypovolaemic shock is associated with a decrease in total peripheral resistance effected by an increase in muscle blood flow. Consequently brain circulation and oxygenation decrease so that the patient or subject faints. On a local level, the regulation of muscle and brain blood flow differ in that although muscle blood flow increases during exercise, the increase is not large enough to prevent a decrease in venous and muscle oxygenations. Conversely, an increase in regional cerebral activity is associated with an increase in regional cerebral blood flow to an extent that the regional oxygenation of the brain is enhanced. During exercise cerebral perfusion and oxygenation present a picture similar to the skeletal muscles, i.e. in the event of a limiting cardiac output both parameters are compromised. The aim of these studies is to elucidate brain metabolism with respect to "central fatigue" and hormonal control during exercise.

Recent publications related to the projects described above:

Secher, N.H., J.P. Clausen, K Klausen, I. Noer & J. Trap-Jensen. Central and regional circulatory effects of adding arm exercise to leg exercise. ***Acta Physiol. Scand.*** 100: 288-297, 1977.

Rasmussen, A., C. Skak, M. Kristensen, P. Ott, P. Kirkegaard & N.H. Secher. Preserved arterial flow secures hepatic oxygenation during haemorrhage in the pig. ***J. Physiol.*** 516: 539-548, 1999.

Nielsen, H.B., R. Boushel, P. Madsen & N.H. Secher. Cerebral desaturation during exercise reversed by O_2 supplementation. ***Am. J. Physiol.*** 277: H1045-H1052, 1999.

Ide, K, R.B. Boushel, H. Møller-Sørensen, A. Fernandes, Y. Cai, F. Pott & N.H. Secher. Middle cerebral artery blood velocity during exercise with beta-1 adrenergic and unilateral stellate ganglion blockade in humans. ***Acta Physiol Scand*** 170: 33-38, 2000.

Querry, R.G., S.A. Smith, M. Strømstad, K. Ide, P.B. Raven & N.H. Secher. Neural blockade during exercise augments central command's contribution to carotid baroreflex resetting. ***Am. J. Physiol.*** 280: H1635-H1644, 2001.

Querry, R.G, S.A. Smith, M. Strømstad, K. Ide, N.H. Secher & P.B. Raven. Anatomical and functional characteristics of carotid sinus stimulation in humans. ***Am. J. Physiol.*** 280: H2390-H2398, 2001.

Fadel, P.J., M. Strømstad, J. Hansen, M. Sander, K. Horn, S. Ogoh, M.L. Smith, N.H. Secher & P.B. Raven. Arterial baroreflex control of sympathetic nerve activity during acute hypotension: effect of fitness. ***Am. J. Physiol.*** 280: H2524-H2532, 2001.

Gallagher, K.M., P.J. Fadel, M. Strømstad, K. Ide, S.A. Smith, R.G. Querry, P.B. Raven & N.H. Secher. Effects of partial neuromuscular blockade on carotid baroreflex function during exercise in humans. ***J. Physiol.*** 533: 861-870, 2001.

Gallagher, K.M., P.J. Fadel, M. Strømstad, K. Ide, S.A. Smith, R.G. Querry, N.H. Secher & P.B. Raven. Effect of exercise pressor reflex activation on carotid baroreflex function during exercise in humans. ***J. Physiol.*** 533: 871-880, 2001.

Van Lieshout, J.J., F. Pott, P.L. Madsen, J. van Goudoever & N.H. Secher. Muscle tensing during standing: Effect on cerebral artery blood velocity and oxygenation. ***Stroke*** 32: 1546-1551, 2001.

Cai,Y., A. Zimmerman, S. Ladefoed & N.H. Secher. Can haemodialysis-induced hypotension be predicted? ***Nephron*** 92: 582-588, 2002.

Volianitis, S. & N.H. Secher. Arm blood flow and metabolism during arm and combined arm and leg exercise in humans. ***J. Physiol.*** in press, 2002.

Fadel, P.J., M. Strømstad, D.W. Way, S.A. Smith, P.B. Raven & N.H. Secher. New insights into differential baroreflex control of heart rate in humans. ***Am. J. Physiol.*** *(Heart Circ Physiol)* in press, 2002.