Glossary

Autonomic regulation Regulation by the autonomic nervous system. This system regulates a number of cardiovascular and other quantities. Cardiovascular quantities regulated include heart rate, cardiac contractility, resistance, compliance, and unstressed volume. Cardiovascular autonomic regulation is mediated by the baroreflex system, via the sympathetic and parasympathetic systems.

Baroreflex regulation Regulation mediated via stimulation of the baroreceptors which are stretch sensors located in the blood vessels of most mammals. In humans high-pressure receptors can be found in the aortic arch and the carotid sinuses, and low-pressure receptors can be found in large systemic veins, in pulmonary arteries, and in the walls of the right atrium. In response to stretch due to pressure change, baroreceptors induce changes in sympathetic and parasympathetic outflow, which in turn give rise to changes in heart rate, cardiac contractility, vascular tone (primarily through high-pressure receptors) and unstressed volume and blood volume (primarily through low-pressure) receptors.

Blood gases Gases transported in the blood; typically used to refer to the blood gases oxygen and carbon dioxide involved in respiration.

Cerebral autoregulation Autoregulation occurring in the brain. The brain autoregulates to maintain blood flow despite changes in blood pressure. It is believed that autoregulation is primarily mediated via myogenic and metabolic regulation.

Cheyne-Stokes breathing A respiratory abnormality characterized by alternate periods of hyperventilation and apnea.

Closed loop model A model where the outputs of the model are incorporated in a feedback loop to influence system response or function (compare open loop).

Euvolemia Normal amount of intravascular volume for a given body size.

Exercise hyperpnea Increase in respiratory ventilation in proportion to metabolic demand without essential deviation of blood CO_2 tension during muscular exercise.

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It is in contrast to chemoreflex in which ventilation increases in proportion to change in blood CO_2 tension.

Head-up tilt A laboratory test to examine the cardiovascular response to orthostasis. The test passively tilts a subject from supine to approximately 70° angle.

Homeostasis The property of a system to regulate its internal environment in order to maintain a stable and constant condition.

Hypovolemia Reduced amount of intravascular volume for a given body size.

Ill-conditioned estimation Parameter estimation problem in which the numerical values of the parameter estimates depend strongly on small changes in input data.

Inverse problem A general framework for using observed measurements to infer information about the system under investigation.

Kalman filter A set of mathematical equations for estimating the state of a process, taking explicitly into account measurement errors and taking measurement data into account incrementally (on-line estimation).

Metabolic regulation Regulation of local blood flow mediated via enzymes regulating metabolic pathways in response to changes in the cell's environment, level of metabolism, or signals from other cells. In the cerebral vasculature, for example, an increase in tissue metabolism in an activated nerve area will induce an increase in local blood flow, providing an increase in oxygen and nutrients to the tissues. A subsequent reduction in activity results in blood vessels constriction with local blood flow returning to normal.

Model validation The process of testing the correctness of a model. This involves many steps including testing for reasonable model behavior in a variety of conditions with all state variables producing consistent and physiologically reasonable outputs for reasonable parameter values. In essence, one searches for the conditions under which the model behaves appropriately. This domain of validity will depend on (simplifying) model assumptions which in turn depend on the goal for which the model is developed. Often, a narrower meaning is given to validation which involves using portions of available data for parameter estimation and then using the estimated parameters with the remaining data to verify that the model can predict additional observed responses. One method used for model validation includes K-fold cross-validation.

Multiscale modeling Model design containing multiple scales. These can be multiple scales in time or in space. Examples include models coupling 3D spatial and 1D spatial components, models with both higher dimensions and zero-D models, or models including several scales in time, e.g., a model having some components that resolve dynamics over seconds and other components that resolve over hours.

Myogenic regulation The myogenic response (also called the Bayliss effect) regulates contraction of smooth muscles in response to stretch. In the cerebral vasculature, this effect is mainly seen in the arterioles, where an increase in blood pressure causes distension of the arterioles, in response the smooth muscles are constricted. This effect is mediated via calcium signaling and acts to smooth changes induced by perturbations in blood pressure.

Open loop model A model formulation in which the outputs of the model are not used to influence system response. Only arbitrary independently chosen model inputs can be applied to the model to influence the system response.

Orthostatic intolerance Inability to maintain an upright posture without developing cardiorespiratory signs of impending loss of consciousness (such as dizziness) and potentially leading to actual syncope.

Parameter estimation The process of obtaining values for a set of parameters given a model and available data. Typically, the process is carried out using optimization techniques that usually minimize the least squares cost (the sum of squared errors between the observed and computed quantities). Several problems can arise for parameters that are insensitive (i.e., a change in a given parameter does not affect the observed output). In addition parameters may be functionally dependent which can make their unique estimation impossible.

Parameter identifiability This term indicates that the parameters of a model can be identified from the knowledge of model behavior for certain scenarios assuming perfect data reflecting such scenarios.

Parasympathetic regulation A part of the autonomic nervous system. It is activated via the baroreceptors and function via regulation of acetylcholine. In the cardiovascular system parasympathetic regulation mainly impacts heart rate. Parasympathetic regulation of heart rate is mediated via the Vagus nerve. Parasympathetic regulation is almost immediate and the effect on heart rate can be observed within one cardiac cycle from the sensed change in blood pressure.

Periodic breathing Waxing and waning of breathing in a visually cyclic (but not truly periodic) manner.

Physiological respiratory dead space Total wasted ventilation in non-perfused, under-perfused, or poorly-mixed alveolar units.

Respiration The term respiration is used in several ways. It can refer at the cellular level to the process of generating energy including aerobic respiration (using oxygen and generating carbon dioxide) and anaerobic (not using oxygen). It can also refer to the total process of transporting and exchanging oxygen and carbon dioxide between the environment and the cell in the process of generating energy. Hence, terms exist for internal respiration (exchange of blood gases between the cell-extracellular fluid boundary) and external respiration (exchange at the alveolar-capillary boundary) to distinguish individual steps in the process. This term is often

used interchangeably with ventilation which is really only one aspect of respiration (see ventilation). Cellular respiration restricted to the aerobic process represents intercellular exchange of oxygen and carbon dioxide (producing as well energy and water).

Sensitivity analysis A study of how the variation in the parameters of a mathematical model will impact a particular measured state variable.

Shunt (right-to-left) Portion of blood flow bypassing the lung unit, representing a perfused but non-ventilated gas exchange unit. The shunt brings venous blood with high CO_2 tension to the arterial blood, hence elevating arterial CO_2 tension.

Sit-to-stand A physiological stress test (similar to head-up tilt) often used in the clinic to test the cardiovascular control system. During sit-to-stand test clinicians often measure dynamics (beat-to-beat) values for blood pressure, heart rate, blood flow, and quantities related to respiration including expiratory concentration of O_2 and CO_2, as well as airflow.

Sleep apnea Pathological state characterized by cessation of breathing which occurs repetitively during sleep.

Subset selection Determination of a subset of model parameters that can be estimated reliably from experimental data.

Sympathetic regulation A part of the autonomic nervous system. It is activated via the baroreceptors and function via regulation of noradrenaline (or norephinephrine). In the cardiovascular system, sympathetic regulation impact heart rate, cardiac contractility, and vascular tone. Regulation of these quantities is mediated by the ganglionic nervous system, and it typically takes 5–10 s from the sensed change in blood pressure to the actual control of the effector organs.

Transcranial Doppler A test that measures the velocity of blood flow through the brain's blood vessels. Typically, flow is measured in the middle cerebral arteries, though the test also allows for measurement in anterior and posterior cerebral arteries.

Unscented transformation A practical method to estimate the statistics of a random variable undergoing a nonlinear transformation.

Vascular tone This refers to the degree of constriction experienced by a blood vessel relative to its maximally dilated state. All arteries and under basal conditions exhibit some degree of smooth muscle contraction that determines the diameter, and hence tone, of the vessel.

Ventilation The movement of air into and out of the lungs (the process of breathing). Minute ventilation is a measure in liters per minute. Tidal volume is a single inhalation or exhalation measured in liters per breath. Compare to the term Respiration.

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