of Directors in Senzime AB (Uppsala, Sweden); serves as a member of the Board of Directors for Anesthesia Patient Safety Foundation (Rochester, Minnesota); is a member of the Scientific Advisory Board for ClearLine MD (Woburn, Massachusetts) and The Doctors Company (Napa, California); and has a patent-licensing agreement with Mayo Clinic (Rochester, Minnesota). Dr. Kopman declares no competing interests.

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Intraoperative Mean Arterial Pressure Targets: Can Databases Give Us a Universally Valid "Magic Number" or Does Physiology Still Apply for the Individual Patient?

To the Editor:

With great interest we read the article by Salmasi *et al.*[1] reporting the results of a database study investigating the relationship between acute postoperative kidney and myocardial injury and intraoperative hypotension (IOH) either defined as a reduction from baseline mean arterial pressure (MAP) or absolute MAP thresholds. The authors, again, need to be commended for providing another piece of the puzzle on how to better define and understand IOH using their impressive database. In line with other data,[2] this study demonstrates a gradually increasing risk for both kidney and myocardial injury for longer exposure beneath certain MAP thresholds (both absolute or relative) and therefore adds to the evidence that IOH-associated organ failure is a function of hypotension and time.[3] Yet, the main new question this study aimed to answer was whether a definition of IOH should be based on absolute MAP thresholds or on a relative decline from baseline MAP. The authors' conclusion seems to make our daily practice as anesthesiologists very easy: "a strategy aimed at maintaining MAP above 65 mmHg appears to be as good as one based on the percentage reduction from baseline."[1]

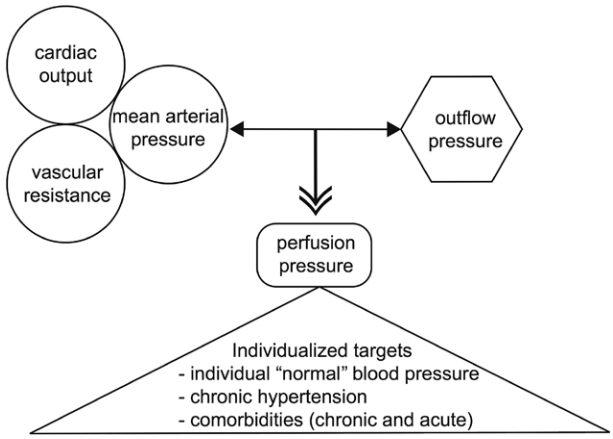

Fig. 1. Individualized perfusion pressure targets. This figure illustrates that perfusion pressure depends on inflow pressure (mean arterial pressure) and outflow pressure. Mean arterial pressure, in turn, is a function of blood flow (cardiac output) and systemic vascular resistance. Individualized targets for perfusion pressure should consider individual "normal" blood pressure, chronic hypertension, and chronic and acute comorbidities.

This database study has many strengths and provides robust results based on sound statistical analyses accounting for many confounding clinical factors. In contrast to many previous studies that used preinduction MAP as "baseline value," the authors defined baseline MAP as "average of all MAP readings in the 6 months before surgery, excluding measurements during a hospital stay."[1] Given the fact that a very recent study[4] again emphasized that preinduction MAP is markedly higher than "normal" preoperative MAP, this chosen definition is very thoughtful. That said, we would like to take the position of the devil's advocate and question the authors' conclusions about the indiscriminate use of an absolute MAP threshold of 65 mmHg in all patients.

The patient characteristics as well as the C-statistic suggest that this study included a highly heterogeneous group of patients with many potential confounding factors that might have influenced the association between MAP and IOH. If clinicians take the authors' conclusion about intraoperative blood pressure management based on a single, universally valid "magic number" (absolute MAP target of 65 mmHg) literally, this might put individual patients at marked risk of hypoperfusion and organ failure for several reasons related to cardiovascular physiology:

First, perfusion pressure—not blood pressure—is our ultimate target during perioperative hemodynamic management. As perfusion pressure is "inflow pressure" (*i.e.*, MAP) minus "outflow pressure" (fig. 1), no general MAP targets can be recommended but MAP must be adjusted considering the individual patient's outflow pressures (*e.g.*, central venous pressure, intrathoracic pressure, intra-abdominal pressure). For instance, a patient with high intra-abdominal

pressure undergoing abdominal surgery might be at relevant risk for renal hypoperfusion and kidney failure if a fixed MAP target of 65 mmHg was applied. The same holds true for cerebral hypoperfusion in a patient with elevated intracranial pressure.

Second, when setting a MAP target we must keep in mind that MAP is a function of blood flow (cardiac output) and vascular resistance. MAP values of 65 mmHg are not the same in (*a*) a surgical patient with distributive shock and hyperdynamic circulatory failure, (*b*) an emergency cardiac surgery patient undergoing off-pump coronary artery bypass surgery, or (*c*) a healthy young patient undergoing otolaryngologic surgery.

Third, some organ systems autoregulate their blood flow according to the metabolic demands and—within certain limits—maintain constant blood flow despite changes in perfusion pressure (autoregulation). In patients with arterial hypertension, the autoregulation curve (*x*-axis, perfusion pressure; *y*-axis, blood flow) is shifted to the right; this means that the lower limit of autoregulation at which blood flow almost completely depends on perfusion pressure is shifted to higher perfusion pressure (and thus MAP) values. In this context, Asfar *et al.*[5] demonstrated in a multicenter randomized trial evaluating low (65 to 70 mmHg) *versus* high (80 to 85 mmHg) MAP targets in patients with septic shock that patients with chronic hypertension required less renal replacement therapy in the high-pressure group compared with the low-pressure group.

Finally, there are very scarce data on the relationship between individual "normal" blood pressure (*e.g.*, from ambulatory 24-h blood pressure measurements) and perioperative blood pressure.[6,7] These data are needed to be able to provide individualized perioperative blood pressure management instead of a "one size fits all approach."

From a physiologic point of view, MAP targets (and finally targets for perfusion pressure) can only be set individually considering outflow pressure of different organ systems, cardiac output, vascular resistance, and blood flow autoregulation in the context of chronic hypertension and other comorbidities. We should be very cautious with suggesting that "anesthesiologists can manage intraoperative blood pressure without reference to preoperative values."[1] For the individual patient, database-derived rules applied to complex cardiovascular physiology can have deleterious effects.

Competing Interests

Dr. Saugel collaborates with Pulsion Medical Systems SE (Feldkirchen, Germany) as a member of the medical advisory board and has received honoraria for lectures and refunds of travel expenses from Pulsion Medical Systems SE. He received institutional research grants, unrestricted research grants, and refunds of travel expenses from Tensys Medical, Inc. (San Diego, California). Dr. Saugel also received honoraria for lectures and refunds of travel expenses from CNSystems Medizintechnik AG (Graz, Austria) and research support from Edwards Lifesciences (Irvine, California). Dr. Reuter collaborates with Pulsion Medical Systems SE as a member of the medical advisory board and received honoraria for lectures and refunds of travel expenses from Pulsion Medical Systems SE. Dr. Reuter also consulted for Masimo Corp. (Irvine, California). Mr. Reese declares no competing interests.

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In Reply:

Nothing in our article[1] suggests that some patients cannot safely be maintained at intraoperative mean arterial pressures less than 65 mmHg. For example, some patients come to surgery with pressures at about that level and will presumably tolerate at least somewhat lower ones. Similarly, some patients may require higher pressures—presumably those with conditions that restrict organ perfusion. Importantly, the article to which Saugel and colleagues refer evaluated myocardial injury and acute kidney injury; we have previously reported associations between mean arterial