In this era when aging baby boomers with a modicum of vigor and fitness are eager to trumpet their youthful vigor (such as myself), most will downgrade their age by at least two decades mocking their approaching mortality (as if they actually have control anyway!). However, in the management of intraoperative blood pressure, accumulating evidence suggests that we may well do better for our patients by bucking this narcissistic trend and upgrade our prior assumptions of what we have previously considered safe. Thus, perhaps we should be adding 10 to 20 mmHg to the current minimal acceptable intraoperative mean arterial pressure for higher-risk patients we anesthetize and should strive to keep it there as best as we can, for as long as we can.

In this issue of Anesthesiology, van Waes et al.1 continue the evolutionary progression over the past decade of well-analyzed observational reports clustered in this journal,1–10 examining the methodological controversies and the actual association of intraoperative hemodynamics (in this case focusing on blood pressure) to perioperative outcomes (in this case primarily myocardial injury). The authors have pooled data from two university centers with standing protocols for “routine troponin surveillance” for patients undergoing vascular surgery (although with slightly different timing), making their study unique among prior reports where troponin sampling was triggered by clinical events subjecting it to selection bias. In approximately 900 patients, they were able to model associations of either absolute or relative changes in mean arterial pressure in relation to immediate preinduction values. In the small percent of patients where these data were not available, the analysis was restricted to absolute threshold criteria. They also assessed the cumulative duration of such changes (including consideration of the commonly used “area under the curve” parameter). These measures were related to the primary outcome of postoperative myocardial injury (using well-established criteria) after appropriate adjustment for a battery of risk factors and potential confounders (including mean heart rates). Of the four thresholds previously defined by the seminal work of Bijker et al.,2 the one that appears to maintain the best consistency with the primary outcome is a 40% decrease in mean arterial pressure from the preinduction baseline for a cumulative duration of 30 min (relative risk of 1.8). Notably, cumulative durations less than 30 min were not associated with myocardial injury.

This is a unique collaboration of two groups of investigators with a pedigree of excellence in epidemiologic analyses of cardiovascular outcomes. However, proper clinical extrapolation of these findings requires recognition of the high-risk characteristics of this cohort with an average age of 73 yr (well above the 60 to 65 number often used to define “elderly” in contemporary studies): two thirds underwent high-risk surgery (as defined by the revised Cardiac Risk Index),11 50% were classified as American Society of Anesthesiologists class IV, and one third underwent “emergency surgery.” Perhaps most importantly, the baseline mean arterial pressure was quite high at 103 mmHg (SD: 16 mmHg), and the baseline mean arterial pressure of those with intraoperative hypotension greater than 30 min was very high at 118 mmHg (SD: 13 mmHg). These are perhaps the “sickest of the sick,” at least in the realm of patients with probable atherosclerotic disease of key vital organs (heart, brain, and kidney). As such, these findings should not trigger grave concern of cardiac damage in younger healthier patients undergoing many other types of surgery. However, most clinicians deal with patient populations poised midway...
in risk between these extremes, and thus such results should encourage a renewed interest in how hypotension may influence outcome in the majority of patients under our care. It is probable that these patients may sustain lesser degrees of troponin elevation (or other organ damage) along a “dose-response” curve of cumulative blood pressure reduction. Yet, a single observational analysis should not form the basis for a marked shift in clinical practice until other factors involved in clinical decision-making and multiple studies reveal the same findings. In this regard, the authors have done an excellent job of listing the limitations of this analysis including the lack of some clinical variables of interest, most notably how such episodes were treated, some missing baseline blood pressure data, and lack of preoperative troponin data (to rule out preexisting damage being inappropriately counted as a study outcome). It is also worth noting that a significant association between the primary outcome and one of the centers was observed (a so-called “center effect”) and thus even generalizing the results within this actual study is potentially problematic although such variability between centers has been previously documented by others. In addition, a risk-adjusted association between preoperative β-blockade and outcome was noted, which might add fuel to the fire regarding the efficacy and safety of perioperative β-blockade, but this post hoc association is subject to unacceptable bias in this type of study design. Limitations aside, this study adds important information for us to consider in managing these sick patients and begs not only for additional analyses incorporating more centers, larger numbers of patients, more careful consideration of the complexities of what is a “baseline blood pressure” (e.g., ambulatory outpatient data) but also consideration of the precise timing of such episodes to anesthetic and surgical events (e.g., induction and maintenance agents, fluid administration, vasopressor use, bleeding episodes, and aortic or other cross-clamping or declamping episodes). The multidimensional nature of modeling baseline risk and anesthetic and surgical practice along with random variation is daunting, but this, along with other recent studies in the journal, is an excellent step forward. It also adds impetus to the need for randomized trials of specific clinical management strategies to more precisely assess whether these associations are indeed causal or due to residual confounding.

Clearly there are valid, and at times absolutely indicated, reasons for substantially lowering a patient’s blood pressure well below their baseline based on a clinician’s assessment of the relative risks and benefits (e.g., acute surgical bleeding, a fragile vascular anastomosis, severe mitral or aortic regurgitation causing heart failure, etc.). Indeed, in many complex cases and daily in the management of patients undergoing cardiac surgical procedures, clinicians have to “let the pressure ride” while the surgeon is obstructing some facet of the cardiovascular system. However, we have little else besides clinical intuition and rudimentary physiologic principles to guide us. The word “hypotension” is only mentioned several times in the influential American College of Cardiology/American Heart Association Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery, all in the context of preexisting conditions or as a potential consequence of several different classes of medical drug administration. Although observational studies such as this make a “neat and tidy” package of measuring absolute or relative changes in blood pressure, the complexities of assessing the multiple physiologic factors determining arterial pressure and its distribution among different vascular beds, let alone technical issues associated with its measurement (as so eloquently reviewed recently by Magder), should make us pause and reflect on potential gaps in our current knowledge.

Our contemporary practices and decision-making for manipulation of acceptable intraoperative blood pressure are clearly more evolved than those of our predecessors in clinical practice. In a presentation to the 26th Annual Congress of Anaesthetists in London in 1951, Organe opined on the risks and benefits of hypotension during anesthesia to reduce surgical bleeding, notably in patients undergoing “extensive operations through tissue planes ... prostatectomy, lumbar sympatheticctomy, laminectomy, and some craniotomies...”. He noted that “it has been claimed that a systolic pressure of 30 mmHg is safe in young and healthy patients” although he apparently has some reservations by stating that “a reduction to 70 mmHg is all that is necessary so that the technique appears to provide a good safety margin.” He goes on to describe an illustrative case closer to the patient population under consideration by van Waes et al. demonstrating a fatal lack of appropriate physiologic knowledge in an unfortunate 65-yr-old male with a preoperative blood pressure of 220/120 mmHg and “heart enlargement” who after pentothal induction was placed in reverse Trendelenburg position with a blood pressure of 40/35 mmHg. He specifically notes that there was “remarkably little bleeding” during incision. Unfortunately, the patient expired on the third postoperative day. In late 1953, the Anaesthetists Committee upon Deaths Associated with Anaesthesia16 reported on an influx of problematic cases after procedures in which hypotensive anesthesia was used although they specifically note, “The committee feel that no general conclusions can be drawn from these instances.” Shortly thereafter, the landmark epidemiologic study by Beecher and Todd, investigating deaths associated with anesthesia and surgery analyzing potential factors in 599,548 anesthetics at 10 university hospitals in the United States (ranging from approximately 1 in 75 to 1 in 2,680 depending on the definition used), was published. Although they considered in eloquent detail multiple “process and structure” factors (e.g., specific drugs, type of anesthesia, type of anesthetist, etc.), they make no mention of intraoperative hemodynamics or potential relations of them to outcome. Although clinical interest in induced hypotension continues to this day, particularly in orthognathic surgery and in some forms of orthopedic surgery, the lessons of the past have shown us that overly aggressive or perhaps more commonly a laissez-faire attitude
toward intraoperative hypotension may indeed be detrimental to our patients’ welfare.

We have clearly come a long way in teasing out critical physiologic factors and their relation to outcome. The excellent work by van Waes et al.1 nicely demonstrates this trajectory and emphasizes the need for randomized trials of this most fundamental of physiologic variables.

Competing Interests
The author is not supported by, nor maintains any financial interest in, any commercial activity that may be associated with the topic of this article.

Correspondence
Address correspondence to Dr. London: martin.london@ucsf.edu

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