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SPECIAL ARTICLE

Perioperative Patients With Hemodynamic Instability: Consensus Recommendations of the Anesthesia Patient Safety Foundation

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In November of 2022, the Anesthesia Patient Safety Foundation held a Consensus Conference on Hemodynamic Instability with invited experts. The objective was to review the science and use expert consensus to produce best practice recommendations to address the issue of perioperative hemodynamic instability. After expert presentations, a modified Delphi process using discussions, voting, and feedback resulted in 17 recommendations regarding advancing the perioperative care of the patient at risk of, or with, hemodynamic instability. There were 17 high-level recommendations. These recommendations related to the following 7 domains: Current Knowledge (5 statements); Preventing Hemodynamic Instability-Related Harm During All Phases of Care (4 statements); Data-Driven Quality Improvement (3 statements); Informing Patients (2 statements); The Importance of Technology (1 statement); Launch a National Campaign (1 statement); and Advancing the Science (1 statement). A summary of the recommendations is presented in Table 1. (Anesth Analg 2023;XXX:00–00)

Recent data document an unacceptable rate of preventable harm in health care. In 2022 the US Department of Health and Human Services Office of Inspector General released a report stating that "Twenty-five percent of Medicare patients experienced patient harm during their hospital stays in October 2018."[1]

The Joint Commission provision of care standard PC.02.01.19 requires that hospitals recognize and respond to changes in a patient's condition in a timely manner.[2] Inpatient monitoring that advances early recognition of clinical deterioration remains critical to effective intervention and prevention of downstream adverse events, and should be considered a core competency of perioperative care. Hemodynamic instability can lead to hypoperfusion and is associated with patient harm. However, there are no specific recommendations to guide the clinician in identifying risk, using essential monitoring, understanding thresholds for specific patients, and effective and timely interventions for improvement.

In November 2022, the Anesthesia Patient Safety Foundation (APSF) held a Consensus Conference with invited experts to address key issues regarding hemodynamic instability. The overarching objective of the conference was to determine consensus recommendations for best practices for preventing harm from hemodynamic instability. Not surprisingly, the conference underscored many questions that remain to be answered before we can fully understand how to define patient-specific risk and determine the best prevention and treatment strategies. However, all the participants agreed there is an opportunity to improve current practices and enhance patient safety. The recommendations presented are intended to assist health care systems and providers in designing approaches to care, pursuing quality improvement initiatives, and conducting research to develop the new knowledge necessary for future improvement. Given the existing gaps in knowledge, these recommendations should not be construed as absolute standards.

METHODS

A conference program was created that involved discussion of key questions concerning

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Table 1. Summary of Recommendations Regarding Advancing the Perioperative Care of the Patient at Risk of, or With, Hemodynamic Instability

Current knowledge

1. All providers need to understand the multifactorial pathophysiology of hemodynamic instability.
2. All providers need to have a clear understanding that early detection, identifying the underlying cause and effective interventions are key to best practice.
3. Emphasize the strong association of poor outcomes with multiple organ systems when hemodynamic instability occurs during perioperative care.
4. Formalize teaching of new types of monitoring, including point of care ultrasound, in postgraduate training programs that enable early detection of hemodynamic instability and precise diagnosis of the underlying cause.
5. Teach appropriate management of hemodynamic instability in a logical approach using fluid, blood products, inotropes, and vasopressors such that treatment most effectively addresses the problem and does not lead to unintended harm.

Preventing hemodynamic instability-related harm during all phases of care

6. The system of care should be well integrated with effective handoffs and best practices for identifying and treating the patient at risk for hemodynamic instability.
7. Operating room
   - Widespread ability to give rapid fluid bolus and to assess volume responsiveness using appropriate monitoring.
   - Allow the use of peripheral norepinephrine.
8. PACU
   - Ability to continue effective monitoring for an extended period, as indicated.
   - Ability to continue vasopressors to maintain hemodynamic goals.
   - Ability to triage for appropriate placement and monitoring.
9. Post-PACU (floor/higher level of care)
   - Continuation of effective monitoring according to the patient risk, surgical risk, and hemodynamic instability.
   - Triage after surgery to appropriate level of care to allow identification and early treatment of hemodynamic instability.
   - Availability of point of care ultrasound.

Data-driven quality improvement

10. Actionable data collected from all types of patients, procedures, and treatment areas with feedback to systems and providers to drive quality improvement
11. Data collection from all types of patients, procedures, and treatment areas to be warehoused in open access for research
12. Research funding to run multicenter clinical efficacy studies to reduce hemodynamic instability and individualize hemodynamic goals to determine if harm can be mitigated

Informing patients

13. A patient Information campaign to engage patients in their care with emphasis on the informed consents regarding risks of surgery
14. Before discharge updating the patient of any downstream risks of hemodynamic instability The importance of technology
15. Fast track new technologies and therapies to accelerate adoption and integration into current practice. Specifically:
   - Improve and implement continuous noninvasive monitoring.
   - Improve monitors that provide real time feedback as to whether an intervention is effective.
   - Encourage monitoring that not only provides early detection but ideally predicts hemodynamic instability.
   - Monitors that are more precise regarding organ perfusion and are individualized for a given patient.
   - Advance wearable technology.
   - Create a wireless agnostic interface between all monitoring systems and EMRs.

Launch a national campaign

16. All stakeholders (national associations, regulatory bodies and patient safety organizations) should work together to disseminate the above recommendations and set a realistic timescale to implement and achieve the above goals

Advancing the science

17. Mature the science supporting clinical care of patients with hemodynamic instability. Ideally this would be multidisciplinary and collaborative. This should involve not only traditional scientific methods but also data science and artificial intelligence.

Abbreviations: EMR, electronic medical records; PACU, post-anesthesia care unit.

perioperative hemodynamic monitoring and hemodynamic instability, presentations on the key components of these topics, and creation of a set of questions and recommendations important for future operational improvements and research plans. A draft version of recommendations was sent to the attendees for feedback. After presentation of evidence from subject matter experts, there was electronic voting to guide discussion in break-out groups. After discussion, these groups then presented their consensus back to the session Chair for summary. The final consensus was formed through 3 rounds of discussion and voting using this modified Delphi process.[3] After the meeting there was a final round of voting on a revised set of questions before finalizing the consensus recommendations based on the whole of the conference discussions and Delphi results.

The following key issues were addressed in the agenda:

- The scope of the problem.
- The optimal data a clinician needs to make effective clinical decisions.
- Technology needs and diagnostic tools that better inform clinical pathways and decisions.

Further details of the consensus development and voting process can be found in Supplemental Digital Content, Supplemental Figure 1, http://links.lww.com/AA/E607.

RESULTS

A summary of the recommendations is presented in Table 1. These recommendations apply throughout the episode of perioperative care. There were 17 high-level recommendations related to the following 7 domains: Current State of Knowledge (5 statements), Preventing Hemodynamic Instability Related Harm During All Phases of Care (4 statements), Data-Driven Quality Improvement (3 statements), Informing Patients (2 statements), The Importance of Technology (1 statement), Launch a National Campaign (1 statement), and Advancing the Science (1 statement). The remainder of this article is structured to provide greater context for each of the above domains (not necessarily specific to each recommendation).

DISCUSSION

Current Knowledge

The Challenge of Defining Hemodynamic Instability. Hemodynamic instability is recognized as a complex syndrome involving many physiological parameters resulting in impaired circulation and oxygen delivery to vital organs. Clinically, hemodynamic instability is commonly characterized by abnormalities of blood pressure, heart rate/rhythm, cardiac output, stroke volume, and central venous pressure; of which blood pressure is the most utilized indicator of hemodynamic instability in the perioperative period.[4] Although not physiologically comprehensive, the current state of clinical practice is primarily focused on diagnosing and treating blood pressure as a surrogate of hemodynamic instability. Accordingly, our emphasis addressed hypotension with the understanding that blood pressure is simply 1 component of a multifaceted system.

Systemic blood pressure is a finely regulated physiological variable that has a complex interaction with cardiac output, systemic vascular resistance, blood volume, heart rate, blood viscosity, elasticity of blood vessels as well as a variety of other physiological factors that contribute to tissue perfusion.[4] Hypotension is common during the perioperative period and is often a late indicator of underlying pathology.[5–7] Too often treatment strategies for hemodynamic instability address temporizing measures that stabilize blood pressure without detecting, identifying, and correcting the underlying cause in a timely manner.

Blood Pressure Thresholds for Injury. The evidence to date would suggest that there is a strong association of hypotension with patient harm.[4,7–14] There is also evidence that fluctuations in heart rate are associated with myocardial injury after noncardiac surgery (MINS).[15] Finally, we know that most events of in-hospital cardiac arrest are preceded by hours of increasing hemodynamic instability.[16,17]

A summary of harm to different organ systems by lowest mean arterial pressure (MAP) and duration can be found in Table 2. Of particular interest is the recently reported Perioperative Ischemic Evaluation-3 (POISE-3) trial. POISE-3 was a prospective, randomized trial that demonstrated no difference in primary composite outcome (MINS, MINS not meeting the universal definition of myocardial infarction [MI], MI, stroke, vascular and all-cause mortality, and other tertiary end points) when targeting an MAP goal of 80 mm Hg as compared to 60 mm Hg.[19] A previous study targeting 60 mm Hg vs 75 mm Hg also did not show any difference in adverse cardiac outcomes.[20] An exact MAP target remains imprecise, an MAP <65 mm Hg increases the rate of harm and an MAP <60 mm Hg has a high probability of harm[18,21] with a dose relationship while an MAP >80 mm Hg appears to confer no advantage.[19]

It is widely acknowledged that the incidence of hypotension varies according to the numerous thresholds used to define it. A systematic review published in 2007 found 48 published definitions of hypotension. These definitions were based on systolic, diastolic, or MAP values, and could be further categorized according to absolute or relative decreases from the patient's baseline blood pressure value.[22] As examples, in noncardiac surgery, acute kidney injury (AKI) and MINS are commonly associated with MAP <60 mm Hg for more than 5 to 10 minutes, or MAP <55 mm Hg for as little as 1 minute[23–25]; whereas MAP <55 mm Hg for more than 20 minutes,[24] or >50% reduction from baseline for more than 5 minutes,[26] are associated with death at 30 days.[18,21] As far as relative thresholds are concerned, a reduction in MAP of more than 20% from baseline is considered clinically significant.[21] Emerging literature also points to the importance of perioperative risk stratification, as high-risk patients are prone to AKI and MINS under milder degrees of hypotension.[14,27–29] A number of studies testing hemodynamic management strategies that take a more comprehensive approach to optimize preload and cardiac index while using vasopressor therapy to target an MAP goal have shown benefit, as opposed to simply "fixing" a blood pressure number.[30–33]

Questions to Consider. Although an association between hemodynamic instability and patient harm is well established, is there a causal relationship? A mechanism for identifying optimal blood pressure goals for specific patients has yet to be identified with acceptable sensitivity and specificity.[34] Moreover, the question of whether blood pressure goals should be defined in absolute or relative terms is unclear and may need to be considered on an individualized basis.[21] However, there are now large population data showing zones of risk for patients undergoing

Table 2. Association of Harm With Degree and Duration of Hypotension Using a Heat Map of Combined Data From 42 Studies

MAP	Duration	Acute kidney injury	Myocardial injury	Mortality
<80 mm Hg	1 min			
	5 min			
	10 min	1.02		1.02
	20 min	1.04		1.04
<75 mm Hg	1 min			
	5 min			
	10 min	1.02		1.02
	20 min	1.09		1.09
<70 mm Hg	1 min			1.002
	5 min			1.01
	10 min			1.04
	20 min			1.09
<65 mm Hg	1 min	1.3	1.01	1.002
	5 min	1.6	1.2	1.01
	10 min	1.6	1.3	1.04
	20 min	2.3	1.8	1.09
<60 mm Hg	1 min	1.3	1.1	1.1
	5 min	1.6	1.2	1.1
	10 min	1.8	1.5	1.1
	20 min	2.3	2.5	1.2
<55 mm Hg	1 min	1.4	1.3	1.2
	5 min	1.6	1.5	1.2
	10 min	2.3	1.8	1.4
	20 min	3.5	2.5	2
<50 mm Hg	1 min	1.6	1.3	1.2
	5 min	1.6	4.4	2.4
	10 min	2.3	4.4	2.4
	20 min	3.5	4.4	2.4
<45 mm Hg	1 min	1.6	1.3	1.2
	5 min	1.6	4.4	2.4
	10 min	2.3	4.4	2.4
	20 min	3.5	4.4	2.4
<40 mm Hg	1 min	3.8	1.3	1.2
	5 min	3.8	4.4	2.4
	10 min	5.1	4.4	2.4
	20 min	5.1	4.4	2.4

The table shows odds ratios for acute kidney injury, myocardial injury, and mortality with different levels and duration of MAPs. Adapted from Wesselink et al.[18]

Abbreviation: MAPs, mean arterial pressures.

elective surgery and emergency general surgery.[10,35] A graphical example of 30-day mortality dependent on the duration of hypotension below certain MAP thresholds and duration in patients was published by Stapelfeldt et al.[36] Beyond specific hemodynamic targets that relate to zones of risk, the duration of the perturbation also appears to affect harm. For instance, reductions in MAP < 70 mm Hg (or possibly 25% of baseline) for more than 10 minutes have been associated with postoperative mortality, and the risk appears to be cumulative with a greater duration of hypotension.[10,11,14,35]

Mortality risk also changes when the comorbidity of hypertension is present[36] Recent data have shown that it is not just patients with comorbidities and high American Society of Anesthesiologists (ASA) physical status that experience perioperative hypotension. Even ASA physical status I and II patients in community anesthesia practice experience hypotension although the consequence of hypotension in these patient groups has yet to be fully understood.[37] This suggests that the challenge to the cardiovascular system by the introduction of anesthetic agents, positive pressure ventilation, surgical stress, and ensuing inflammatory changes may all impair homeostasis. It seems plausible that harm is dependent on an interaction between frailty/resilience of a patient and the actual stress of the perioperative episode of care.[21]

Finally, it is likely that efforts to mitigate perioperative hypotension will come with unintended consequences. As an example, a treatment strategy that simply fixes the blood pressure using vasopressors without appropriate volume optimization can lead to poor perfusion in the splanchnic circulation as demonstrated in microcirculatory studies.[38]

Preventing Hemodynamic Instability-Related Harm During All Phases of Care

Patients are at risk for hemodynamic instability-related harm in all phases of care.[16,17,39,40] It is key that patients have the appropriate level of hemodynamic monitoring throughout their perioperative course to detect physiological triggers indicating harm. Although postoperative morbidity and mortality is relatively high,[41,42] common practice on surgical wards is to assess vital signs at 4- or 6-hour intervals. Turan et al[43] observed that hemodynamic instability is "common, prolonged, profound, and largely undetected by routine vital sign assessments" in the surgical ward. Thus, a more comprehensive approach to monitoring is indicated which may include individualized risk strategy, appropriate triage points across the episode of care, and a continual approach to monitoring. The rapid acceleration and adoption of monitoring technology in the intraoperative period needs to extend to selected patients in the postoperative period in a feasible fashion.

Multidisciplinary engagement requires that all teams understand the need for change, connect phases of care with collective goals, share information and resources, and build communication and support for seamless care integration.

Important steps recognized by the APSF Consensus experts include:

1. Educate all teams on the immediate and downstream effects of hemodynamic instability
2. Identify the changes needed to identify hemodynamic instability and treat if appropriately
3. Align teams with implementing the identified changes.
4. Align the incentives to achieve the expected outcome.
5. Expand individual-level perspectives into a broader-level agenda that builds awareness of each group's needs, barriers, and goals.
6. Increase value congruence between silos and the organization
7. Identify obstacles and adopt design principles to overcome challenges
8. Build forums for feedback to allow open dialogue across teams to foster coordination and connection

The Agency for Health care Research and Quality's list of patient safety tips for hospitals is to build better teams and rapid response systems.[44] This recommendation can be used to develop strategies for addressing hemodynamic instability. Specifically, timeouts incorporating the early identification of patients at high risk of hemodynamic instability, establishing robust protocols for the early identification and treatment of hemodynamic instability, educating clinicians caring for patients in a lower level of care to the requirements of change notification, and empowering all teams to make the necessary change in status decisions.

Patients who die as a result of reversible complications are classified as a failure to rescue (FTR). Less understood is the phenomenon known as failure to escalate. Early warning systems are designed to provide a system for escalating care.[17] These systems integrate monitoring, response, and clinical governance of the deteriorating patient with targeted education programs for health care professionals, and standardized approaches handoffs.

Human factors known to affect the escalation of care processes are communication, culture, and decision-making. Studies have shown that even after several serious adverse events have occurred, in very few instances was the escalation protocol strictly adhered to.[45]

Attention to both clinician and patient factors is important in determining weak links within the hemodynamic escalation trigger system. Clinician variables such as experience represent significant barriers to escalation specifically related to their level of confidence and ability to detect deterioration.[43,45] The other aspect of failure to escalate is the concept of proactivity versus reactivity. The view that many episodes of hemodynamic instability can be minimized if not prevented by the availability and reliability of hypotension prediction monitors and software has been a recurrent theme in literature focused on early warning systems and FTR. Clinically significant hypotension events in many instances can be predicted before the initial hypotension episode,[46] allowing for treatment of the root cause.[16,17] AI has the potential to augment this sensitivity.[47]

Data-Driven Quality Improvement

Centralized data platforms can enable accurate and efficient data collection which can provide quality feedback to hospitals and individual clinicians. The centralized collection of data is crucial for widespread applications across multiple institutions, enables benchmarking, and tracks meaningful change in practice across individuals, departments, and regions. One application of this type of data collection is the development of anesthesia quality measures pertaining to hypotension avoidance that lead to quality improvement efforts.

Examples of quality measures based on centralized data collection include:

- Anesthesia Quality Institute-National Anesthesia Clinical Outcomes Registry (AQI-NACOR) (ePreop31: Intraoperative Hypotension among Non-Emergent Noncardiac Surgical Cases). This set of data can provide information on the demographics of intraoperative hypotension and variation across clinicians but is not detailed enough to understand individual risk factors or patient outcomes.

- Multicenter Perioperative Outcomes Group (MPOG; BP-02: avoiding monitoring gaps and BP-03: low MAP Prevention <65). MPOG offers greater depth than NACOR (in a more narrowed group of facilities), down to the level of individual vital signs and medication doses. MPOG has greater potential to integrate intraoperative processes with postoperative hospital outcomes captured from the electronic medical record (EMR).
- Single-system data. A number of systems have the capacity to collect and analyze data through their EMR covering a large and diverse range of cases, including more detailed assessment of outcomes (eg, creatinine, hemoglobin, and troponin values).
- American College of Surgeons National Surgical Quality Improvement Project. This registry has been in existence for over 20 years and collects 30-day risk-adjusted operative outcomes across 4000+ surgical procedures conducted in the inpatient and outpatient setting in nearly all specialties. Over 800 hospitals in over a dozen countries participate. The data are clinical (as opposed to billing or claims) and provide hundreds of benchmarking reports to identify opportunities for improvement. Published studies have demonstrated improved outcomes for hospitals participating in the program. Over 1000 research studies have been published, including merging National Surgical Quality Improvement Program data with other data sources to increase the robustness and opportunities for research and learning.

Although data on intraoperative hypotension are successfully collected, recorded, and provided as feedback for hospitals participating in the quality institutes and collaboratives discussed above, centralized data collection of postoperative hypotension has been more elusive. Currently, the quality improvement measures have been focused on the intraoperative period, but blood pressure management and hypotension avoidance in the postoperative period is also important.[6,11,14] Finally, continuous quality improvement that includes training and feedback to clinicians will be essential to improving patient outcomes.[48]

Informing Patients

Patients must be a part of the solution! To that end they must actively participate in their care, make truly informed decisions, and work with providers and systems of care to improve outcomes. For patients at risk for hemodynamic instability, a thorough review of potential complications should be part of the preoperative discussion along with a discussion of the strategies that will be used to minimize the risk of harm. Ideally, these discussions would occur at the time of the surgical decision between the surgeon and patient with the intent to foster shared decision-making and reassure the patient that their risks are being considered.

The Importance of Technology

Because intraoperative hypotension is multifactorial, an accurate assessment of the underlying etiology of hypotension will allow for cause-directed therapy. However, the use of "standard" intraoperative monitors alone in many cases renders blood pressure management mainly reactive. More advanced monitoring technology designed to predict hemodynamic instability before it occurs may contribute to our ability to prevent hemodynamic instability. Patient decompensation using a combination of the patient's physiological data using artificial intelligence continues to advance.[47,49] Hypotension prediction from live physiological arterial waveforms has also been successful.[46] Ideally, the sequence of events should be to predict deterioration, and treat the underlying cause with a preemptive intervention before clinical hemodynamic instability throughout all phases of care.

Selecting the most appropriate technology is challenging. Continuous noninvasive blood pressure monitoring has been US Food and Drug Administration (FDA)-approved and evidence suggests that it may offer a method of detecting hypotension earlier than traditional monitoring.[50] Similarly, portable finger cuff-based pulse decomposition analysis technology is validated as a source of continuous cardiac output information and should allow for enhanced noninvasive monitoring during transitions to a lower level of patient care.[51,52] Other technology that has similarly utilized morphology of the electrocardiogram, heart rate variability, and blood pressure to predict critical response events in low-acuity units and new-onset atrial fibrillation is available.[53,54]

Novel biological sensors are currently undergoing investigation. Although there are many challenges to validating and incorporating new hemodynamic parameters into clinical practice and the decision matrix for hemodynamic instability, they show great promise at measuring indices such as fluid responsiveness, autonomic functions, vascular compliance, tissue metabolism, and microcirculatory parameters.[55] Measuring these variables may refine not only the detection of hemodynamic instability but also guide therapeutic interventions.

While monitoring effectively is essential, the information needs to be delivered to providers in a concise and useful manner to guide clinical care as well as research and quality improvement. Achieving this will require integration of live physiological data and patient-specific factors like comorbidities and perioperative status with more complex alerting systems.

The control tower model with integration into the EMR may prove a way of delivering this capability in a cost-effective manner.

Launch a National Campaign

Ideally, all stakeholders involved in the care of surgical/procedural patients would coordinate a comprehensive initiative to disseminate the above recommendations and set a realistic timescale to implement and achieve the above goals.

Implementation begins with education and awareness of the harm associated with hemodynamic instability. Medical societies can advocate at the regulatory level for the inclusion of meaningful quality measures in the Centers for Medicare & Medicaid Services Merit-Based Incentive Payment System. Medical specialties can create guidelines for avoidance of hypotension, both intraoperatively and postoperatively. Reporting of data to national registries must be part of the solution, both to raise awareness of the issue and to create a substrate for future research.

Advancing the Science

Although prevention of intraoperative and postoperative hemodynamic instability may reduce harm, there is a gap in the maturity of the science, as well as the research needed to create new knowledge to guide interventions and make comprehensive standards.

Closing this gap should involve not only traditional scientific methods but also data science and artificial intelligence methodologies. Most research in the domain of hemodynamic instability has focused on outcomes related to intraoperative or intensive care hypotension, and not the recovery period.[7,9,12,56,57] Many studies that have looked at outcomes related to hypotension have focused on AKI and MINS, and less so on other important patient outcomes, such as neurologic outcomes. Another downstream issue of hemodynamic instability that merits evaluation is increased hospital utilization and cost-benefit.[58]

Current literature suggests that continuous monitoring in the low acuity environment detects more abnormalities in vital signs than traditional intermittent spot-check monitoring.[6,14,40] However, it is unknown whether this translates into improved clinical outcomes for patients or whether these changes in vital signs are merely just benign excursions away from an individual patient's baseline. Finally, it is challenging to correctly define a baseline specific to each patient.

With this background, key outstanding research questions that need to be answered or methodological techniques that need to be used include:

1. Prospective interventional trials of continuous monitoring against traditional intermittent monitoring, that are pragmatic, cluster randomized, and that incorporate measurement of interventions.
2. Prospective trials to accurately phenotype baseline blood pressure that would help define blood pressure targets.
3. Using systolic blood pressure, a common measure on the hospital floor that is better understood than MAP which is commonly used in the operating room and intensive care environments.
4. Using noninvasive measures of tissue perfusion, such as perfusion pressure and tissue oxygenation to understand end organ oxygen delivery.
5. Defining and understanding the effects of hypertension in addition to hypotension on hospital floors.
6. Defining and understanding the effects of blood pressure variation.
7. Defining and understanding patient-specific risks of hemodynamic instability.
8. Prospective interventional trials that include traditionally studied outcomes such as AKI and MINS, but also less studied outcomes such as cognition, delirium, patient mobility, rapid response activation, and unplanned intensive care unit (ICU) admissions.

Across all these questions, there is a need for multicenter, pragmatic studies, spanning academic and community hospitals, and including representative samples from appropriate clinical, socioeconomic, and demographic populations.

The Importance of Culture

A final topic was addressed at the conference that did not result in a specific recommendation, was cultural change management. Culture is a set of attitudes, values, goals, and practices that characterize an organization. These integrated patterns of human beliefs and behaviors shape an organization's capacity for learning and the ability to share and transmit knowledge and improvement. Organizations and leaders need to build workplace cultures conducive to change and performance improvement.

A comprehensive guide to change management is beyond the scope of this article but the APSF Consensus Conference identified 2 key health care structures that impact culture (teams and silos). While factors driving teams and silos are also addressed in at-large factors shaping change culture, specific attention was provided to these elements because of their increasing prevalence and influence in health care systems.

Medicine is increasingly focused on teamwork as a means to respond to the challenges of health care delivery more efficiently and productively. Due to the varied knowledge, skill, and behavioral repertoires of each member, teams offer greater flexibility and responsiveness to heterogeneous situations. The "ABCs" of teamwork rely on trust, motivation, psychological safety, mutually accepted values, and behaviors, shared mental models, and memory systems. These processes lead to team potency, improving performance outcomes. Potent teams derive a sense of satisfaction from membership, believe the team can achieve its goal, and are driven by a common and mutually accepted purpose.

Clinical Management

Hemodynamic instability occurs with frequency in the daily care of our patients. The rapidly evolving scientific foundation in combination with the limitations of the data routine monitoring provides throughout the perioperative period precludes the clinician from making highly reliable decisions regarding the root cause of Hemodynamic Instability. Consequently, we are often compelled to make presumptive diagnoses with subsequent interventions that, at times, run the risk of conflicting with the principle of "primum non nocere."

Accordingly, the principal goal of the conference was to assemble a group of experts to evaluate the current data and provide best-practice consensus recommendations to aid clinicians and systems in the clinical management of Hemodynamic Instability. We acknowledge that many questions remain to be answered before we can fully support a standard of care. Thus, we have identified the following as a "best practice" which are organized around both improving systems of care and providing clarity for the individual clinician:

1. System of care: Health care organizations should organize care into a well-integrated and synergistic mesosystem that contains all of microsystems throughout the patient's episode of care (preadmission, preoperative, intraoperative, postoperative, and recovery periods). A microsystem is commonly defined as a highly collaborative, interdisciplinary, and integrated group of health care providers and other stakeholders who work together to provide patient-centric care, enhance outcomes, and use the tools of measurement and feedback to continuously improve. Ideally, care pathways for hemodynamic instability would seamlessly integrate throughout the individual microsystem. Care pathways are best developed at the local level considering the information in this review.
2. Processes: It is a bundle of processes that are embedded in the system of care that matter most. The focus should be on the synergy that develops when we embed multiple processes of improvement, and not search for the "silver bullet." Such processes might best be developed by the local institution in a collaborative manner but might include:
    - Predicting risk throughout the perioperative period (pre-, intra-, and postoperative), with focused resources on the high-risk patient.
    - Mitigating risk throughout the perioperative period and embedding a failure to escalate early warning system throughout the mesosystem.
    - Preempting specific episodes of hemodynamic instability.
    - When hemodynamic instability does occur, treating each episode with disease-specific, targeted interventions that address the underlying cause and not just "fixing" a number.
3. Appropriately monitor patients throughout the perioperative period in a reasonably resourced tier fashion: For many low-risk patients this may only require a noninvasive, automated oscillometric device that intermittently measures blood pressure. Other higher-risk patients may require continuous noninvasive devices that analyze changes in the arterial pressure waveform, or the "gold-standard" for accuracy, an intra-arterial catheter. New technology also provides other data that are derived from waveform analysis (eg, systemic vascular resistance, cardiac output, blood volume, and contractility) that help to determine the root cause of hemodynamic instability. When only monitoring blood pressure as a hemodynamic variable in a patient it is generally agreed that MAP is the best determinant of organ perfusion as a surrogate of flow throughout the entire cardiac cycle.
4. Thresholds for interventions: Based on associative data in large populations a general assumption can be made that the floor for a "safe" blood pressure is a MAP of 65 mm Hg. However, "safe" blood pressure is likely to be highly variable in specific patients and should be modified upward in patients with significant comorbidities or a medical history of hypertension. In other specific populations such as cardiac surgery patients a lower MAP of 60 mm Hg may be adequate.
5. Interventions: As stated previously, disease-specific targeted interventions should be made based on the root cause of hemodynamic instability. Currently, in many cases assumptions are made about the cause of Hemodynamic

Instability (eg, hypotension after induction [vasodilation, cardiac depression]) and a therapy is given based on the assumption. However, in higher-risk patients where assumptions often lead to diagnostic error, greater specificity is required to determine if the root cause(s) are cardiac, vasodilation, or vascular volume. Avoiding assumptions about the root cause(s) is critical when determining the appropriate intervention (vasopressor, inotrope, and/or volume) and treatment may need to be multifaceted. The conference made no attempt to distinguish between the "best" vasoconstrictor, inotrope, or volume to be given and left those judgments based on classic pharmacophysiology in textbooks and the underlying physiology of the patient.

Summary

This should not be the final step in our quest for improvement. A sustained coordinated plan is needed with all stakeholders to reduce the burden of hemodynamic instability and hypotension in our surgical patients.

Patients have a right to health care that is safe, reliable care, and free from harm. The gap between what is and what could be regarding hemodynamic instability is substantial; specifically in the areas of risk stratification, best monitoring to provide the right data for clinical decisions, and correct interventions.

We close with a paraphrased quote from Ellison C. Pierce, Jr, MD, founding president of the APSF:

> *Patient safety is not a fad…. It is not an objective that has been fulfilled... It is an ongoing necessity. It must be sustained by research, training, and daily application in the workplace.*

Our work in safety continues.

DISCLOSURES

Name: Michael J. Scott, MB, ChB.
Contribution: This author helped in the conference planning committee, presenting the conference, developing data acquisition methodology, interpretation of results, writing and revision of the article, and final approval of the article.
Conflicts of Interest: Dr M. J. Scott is the past president of ERAS USA and has served as a consultant for Baxter, Deltex, Edwards, Medtronic, Merck, Phillips, and Trevena in the past 5 years. Dr M. J. Scott has received honoraria and travel expenses for educational lectures from Edwards and Medtronic.
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