reactions during and after insertion of chlorhexidine-impregnated catheters in the operation room, the intensive care unit, and the emergency room.

**Etsuji Terazawa, M.D.**
**Hiroyuki Shimonaka, M.D.**
**Kiyoshi Nagase, M.D.**
**Tatsuhiko Masue, M.D.**
Staff Anesthesiologists
**Shuji Dohi, M.D.**
Professor and Chairman
Department of Anesthesiology and Critical Care Medicine
Gifu University School of Medicine
Tsukasamachi, Gifu, Japan
shu_dohi@cc.gifu-u.ac.jp

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# A Proposal for New Temperature Monitoring and Thermal Management Guidelines

*To the Editor:*—Te last decade has seen publication of hundreds of articles about perioperative thermoregulation, heat balance, and consequences of thermal disturbances. We thus know far more about control of body temperature and the effects of thermal perturbations than when the original Temperature Monitoring Standards of the American Society of Anesthesiologists were introduced. More importantly, four major outcome studies were published in recent years; these studies indicate that even small reductions in intraoperative body temperature produce substantial morbidity in selected patient populations.

We must therefore consider whether revision of the current Temperature Monitoring Standards might be appropriate. To that end, I would like to summarize major recent studies relevant to patient temperature monitoring and thermal management, and their clinical implications. I will then propose a revised set of guidelines based on our current understanding of perioperative temperature control.

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Address reprint requests to Dr. Sessler: Department of Anesthesia, University of California, San Francisco, 374 Parnassus Avenue, 3rd Floor, San Francisco, California 94143-0068.

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## When Intraoperative Temperature Monitoring is Necessary

Normal core temperature varies between 36.5 and 37.5°C. Core temperature usually decreases 0.5–1.5°C in the first 30 min after induction of general anesthesia. Hypothermia results from internal redistribution of heat and various factors, the importance of which is hard to predict in individual patients.[1] As a result, core temperature perturbations during the first 30 min of anesthesia are difficult to interpret.

Significant subsequent decreases in core temperature are most likely in patients undergoing abdominal or thoracic surgery, but malignant hyperthermia—and hyperthermia from other causes—remains a risk in all patients. Consequently, body temperature should be monitored in most patients undergoing general anesthesia that exceeds 30 min. Body temperature ideally might be monitored continuously; however, 15-min intervals probably are sufficient in most patients.

The drugs used during intravenous sedation or regional anesthesia do not trigger malignant hyperthermia. However, core hypothermia occurs during conduction anesthesia,[2] especially when surgery involves major body cavities,[3] and often is manifested as shivering. Core temperature should therefore be measured during spinal or epidural anesthesia in patients who clinicians believe are likely to become hypothermic.

## Where to Monitor Body Temperature

The core thermal compartment is composed of highly perfused tissues, the temperature of which is uniform and high compared with the rest of the body. Temperature in this compartment can be evalu-

ated in the pulmonary artery, the distal esophagus, the tympanic membrane, or the nasopharynx. Even during rapid thermal perturbations (*e.g.*, cardiopulmonary bypass), these temperature monitoring sites remain reliable.* Core temperature can be estimated with reasonable accuracy using oral, axillary, and bladder temperatures, except during extreme thermal perturbations.[4,5]

Skin surface temperatures are considerably lower than core temperature. Skin surface temperatures, when adjusted with an appropriate offset, nonetheless reflect core temperature reasonably well.[6] However, skin temperatures fail to reliably confirm the clinical signs of malignant hyperthermia (tachycardia and hypercarbia) in swine[7] and have not been evaluated for this purpose in humans. Rectal temperature also normally correlates well with core temperature[4] but fails to increase rapidly during malignant hyperthermia crises[7] and during other documented situations.[8] Consequently, rectal and skin surface temperatures must be used with some caution.

## Consequences of Thermal Disturbances

Thermoregulatory responses are impaired by general anesthesia.[9] Intraoperative core body temperature changes are thus largely determined by patient environment. Because the typical operating room is cold and because factors associated with surgery increase heat loss,[10] perioperative hypothermia is common. Mild hypothermia (33–35°C) provides substantial protection from tissue ischemia[11,12] and hypoxemia.[13] It also slows triggering of malignant hyperthermia, and the syndrome is less severe after being triggered in hypothermic swine.[14,15]

In contrast, mild hypothermia (≈2°C below normal) prolongs drug action[16,17] by decreasing metabolism,[18] causes protein wasting,[19] impairs platelet[20] and clotting-cascade enzyme function,[21,22] and triggers postanesthetic shivering[23,24] and thermal discomfort.[24,25] More importantly, core temperatures that are only 1–2°C below normal are associated with adverse patient outcomes. Two groups have shown that mild hypothermia in selected patient populations prolongs postanesthetic recovery,[26] augments bleeding and transfusion requirements,[27] increases morbid myocardial outcomes,[28] and reduces resistance to surgical wound infections and prolonged hospital stay.[29]

The minor and major complications of hypothermia are thus well documented. In some patients mild hypothermia is likely to be dangerous. In others it will be an uncomfortable and slow recovery. I therefore propose that intraoperative core temperatures should usually be maintained at more than 36°C unless hypothermia is specifically indicated.

## Proposed Temperature Monitoring and Thermal Management Guidelines

### *Objective*

To detect thermal disturbances and maintain appropriate body temperature during anesthesia.

### *Methods*

1. Core body temperature should be measured or reliably estimated in most patients given general anesthesia for more than 30 min.
2. Temperature should also be measured or reliably estimated during regional anesthesia when changes in body temperature are intended, anticipated, or suspected.
3. Unless hypothermia is specifically indicated (*e.g.*, for protection against ischemia), efforts should be made to maintain intraoperative core temperature at more than 36°C.

**Daniel I. Sessler, M.D.**
Professor
Department of Anesthesia
University of California
San Francisco, California
Professor
Ludwig Boltzmann Institute for Clinical Anesthesia and Intensive Care
Director, Outcomes Research™ and Vice Chair
Department of Anesthesia and General Intensive Care
University of Vienna
Vienna, Austria
sessler@vaxine.ucsf.edu

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