Inadvertent postoperative hypothermia is common among patients in the postanesthesia care unit (PACU). Shivering traditionally is attributed to hypothermia, but it is not always thermoregulatory. The exact impact of hypothermia and shivering on standard PACU monitoring parameters of patients has not been sufficiently studied.

The present study included 170 orthopedic surgical patients. On PACU arrival, we recorded the incidence of hypothermia and shivering, as well as heart rate, mean arterial blood pressure, and oxygen saturation of all subjects. Analysis of covariance was used to investigate the effects of hypothermia and shivering on these monitoring parameters. Among orthopedic patients, 73.5% of them had hypothermia and 24.7% experienced shivering, which was observed primarily in hypothermic patients. Mean arterial blood pressure was significantly higher in hypothermic patients, and heart rate was significantly higher in shivering patients, whereas oxygen saturation was not affected by hypothermia or shivering.

Our data confirm that standard PACU monitoring parameters are affected partially by hypothermia and shivering. A low incidence of shivering in normothermic patients and a high incidence of shivering in younger patients are discussed. Limitations of this study are reported.

Key words: Core temperature, hypothermia, orthopedic patients, shivering, standard PACU monitoring.

Inadvertent hypothermia in surgery

In humans, body temperature is maintained within narrow limits, even in an adverse environmental temperature. Thermoregulation, which prevents cellular and tissue dysfunction, occurs in 3 phases: afferent thermal sensing, central processing, and efferent responses. Thermoregulatory responses to cold are characterized by altered behavior, cutaneous vasoconstriction, shivering, and non–shivering thermogenesis.1

The strict physiological definition of hypothermia in humans is a core temperature more than 1 SD less than the mean value under resting conditions in a thermoneutral environment.2 Core temperature, which is the blood temperature in the central circulatory system (heart, lungs, brainstem), can be measured reliably at the pulmonary artery, esophagus, or tympanic membrane.3 Normal human core temperature may range from 36.5°C to 37.5°C. Most studies consider hypothermia to appear at a body core temperature less than 36°C (96.8°F).3,5

Perioperatively, inadvertent hypothermia results from the following:6: (1) increased heat loss due to exposure of the body surface to a low-temperature environment and (2) a disorder of normal thermoregulatory mechanisms, resulting in vasodilation and lack of muscular tone, due to the action of general anesthetic agents (intravenous agents, volatile anesthetics, muscle relaxants) or regional anesthesia.

The incidence of inadvertent hypothermia ranges from 60% to 90% of postoperative cases.7,8 Many risk factors have been associated with the development of hypothermia. These include being elderly9,10 or female,11 an ASA physical status of 3 or 4,12 general anesthesia,13 type of surgery11 (open thoracic or abdominal cavity), duration of surgery of more than 2 hours,14 an operating room temperature less than 26°C (78.8°F),10,15 low body weight, history of chronic diseases3 (especially endocrine), and intravenous infusion of cold fluids.

During surgery, the overt symptoms of hypothermia in patients are masked by the administration of anesthetic medications used. This explains why hypothermia often is discovered in the postanesthesia care unit (PACU), when the effects of these medications are wearing off.16 Moreover, the risk of hypothermia tends to be underestimated during surgical procedures of low severity and short duration. Medical and nursing staff members usually are not aware of the fact that the reduction of core temperature during the first hour of anesthesia primarily comes as a result of redistribution, that is, internal heat flow from the warmer core to the colder periphery.17,18 This explains why patients who undergo minor procedures have a higher risk of developing hypothermia.
Complications of hypothermia

Hypothermia is associated with significant postoperative morbidity. The most frequent adverse outcomes of the immediate postoperative period are postanesthetic shivering, markedly impaired thermal comfort, and prolonged time of recovery and PACU stay.21

Postoperative wound infection22 and myocardial ischemia, although relatively rare, are reported as the most severe complications of hypothermia.

Postanesthetic shivering

Postanesthetic shivering is spontaneous, involuntary, and unpredictable muscular activity, affecting up to 65% of patients after general anesthesia and 33% of patients after regional anesthesia.20 When muscle tone increases to more than a critical level, shivering begins with synchronous contractions of small groups of opposing motor units. General theory assumes the cause of shivering to be a classic thermoregulatory response against core or skin hypothermia caused by perioperative heat loss.24 It is initiated by impulses from the hypothalamus to increase heat production. Although cold-induced shivering is an obvious source of postanesthetic tremor, some of it is believed to be nonthermoregulatory because it also is observed in normothermic patients.23 According to electromyographic studies, shivering is composed of 2 distinct patterns of muscular activity: a tonic pattern with 4 to 8 cycles per minute (thermoregulatory) and a clonic pattern, 5 to 7 Hz (uninhibited spinal reflexes). Its exact cause remains unknown, and it has been attributed to other factors, such as general anesthetic drugs, which decrease vasoconstriction and shivering thresholds; pain; loss of descending cortical control; and decreased sympathetic nervous system activity.28

Standard PACU monitoring

Standard monitoring of patients in the PACU includes constant observation of the electrocardiogram, heart rate, arterial blood pressure, and oxygen saturation.29 Monitoring of these parameters is considered desirable for the following reasons: (1) It does not require invasive methods; thus, it is easy to apply to all patients. (2) The electrocardiogram, heart rate, and arterial blood pressure are proper indicators of cardiovascular function, so hemodynamic instability can be detected at early stages. (3) Pulse oximetry is a simple, quantitative method of assessing oxygenation and preventing respiratory complications, such as hypoxemia and hypoventilation. Oxygen saturation should be monitored continuously in all patients recovering from anesthesia.

The exact impact of postoperative hypothermia and shivering on physiologic functions that affect standard PACU monitoring parameters remains unknown. Although some mechanisms have been proposed, studies reported in the literature do not lead to definite conclusions. When a patient begins to regain normal thermoregulation, metabolism significantly increases and heat is produced. Postoperative thermal discomfort is stressful and leads to the release of stress hormones and the elevation of the plasma catecholamine concentration. Increased levels of norepinephrine increase the heart rate and blood pressure, and subsequent vasoconstriction contributes to hypertension.10 It is stated that 87% to 92% of postoperative hypertension in otherwise normotensive patients is caused by hypothermia, duration of surgery, and anesthesia, and hypothermia is the only treatable cause.31

Postanesthetic shivering is an important patient stressor that may be responsible for cardiovascular stress and lead to complications during the postoperative period.2 It has been found to increase oxygen consumption, carbon dioxide production, and cardiac output. These factors can contribute to hypoxemia, myocardial ischemia, and myocardial infarction in elderly and other high-risk patients. However, hypoxemia itself seems to inhibit shivering.32 Supplemental oxygen, skin surface warming, and pharmacological agents, such as opioids,13 are necessary for the treatment of shivering patients. Significant reductions of heart rate and mean arterial blood pressure also have been measured at the end of shivering.33

Aims of the study

The aims of the present study were to (1) count the proportion of orthopedic surgical patients who arrive hypothermic or shivering in the PACU and determine whether these conditions are correlated to any patient or operation characteristics, and (2) study whether heart rate, mean arterial blood pressure, and oxygen saturation are affected by hypothermia or shivering in the immediate postoperative period (PACU arrival).

Materials and methods

• Population and research design. The present study was conducted in the PACU of the General University Hospital of Patras, Patras, Greece, from August 1, 2003 to November 30, 2003. General University Hospital of Patras is a 700-bed, tertiary care academic hospital with 12 operating rooms. After surgery, all patients who received general or regional anesthesia are admitted to a phase 1 PACU (except those who are sent directly to the intensive care unit), where they are properly monitored and treated.
Orthopedic surgical patients older than 18 years constituted the study population. We excluded the following groups of patients: (1) admitted to surgery for emergency procedures, (2) core temperature at the beginning of the operation not within the normal range of 36.0°C to 37.5°C (96.8°F-99.5°F), (3) arrived intubated in the PACU, and (4) needed blood transfusion due to severe intraoperative blood loss because heart rate and mean arterial blood pressure can be affected by major alterations of blood volume.

Demographic data recorded for all patients on PACU arrival included age, sex, ASA classification, anesthetic technique (general or regional), total time in the operating room, and the operating room temperature (measured by a wall quicksilver thermometer).

In the present study, the core temperature threshold for hypothermia was set at 36°C (96.8°F). Temperature was measured at the tympanic membrane by using the Thermoscan (Thermoscan, San Diego, Calif). The tympanic membrane has been proved to provide an accurate assessment and a convenient way to measure core temperature, and this method is well tolerated by extubated patients. The core temperature of all patients was measured just after arrival in the PACU.

Shivering was defined as a detectable fasciculation or tremor of the face, jaw, head, trunk, or extremities and was recorded as present or absent (no visual analogue scale was used). On PACU arrival, all patients were observed carefully for the presence of shivering. Heart rate, mean arterial blood pressure, and oxygen saturation were measured by using the Dinamap Pro 300 (Criticon, Tampa, Fla). Measurements started when patients were admitted to the operating room. Arterial blood pressure was automatically measured in the left arm every 3 to 5 minutes, using the Korotkoff technique. Heart rate and oxygen saturation were monitored continually throughout the operation. The tidal volume, inspired oxygen concentration, and end-expiratory carbon dioxide level of all patients undergoing general anesthesia also were continually monitored, and no cases of severe hypoxemia or hypercarbia were observed.

For patients undergoing general anesthesia, intravenous administration of propofol, fentanyl, and cisatracurium was used for induction. Anesthesia was maintained by 50% nitrous oxide in oxygen, sevoflurane, and remifentanil. For patients undergoing regional anesthesia, spinal administration of levobupivacaine (Chirocaine) 5%, 10 to 15 mg, was used. An epidural catheter was used only for postoperative analgesia. Isotonic crystalloid solutions were given intravenously at room temperature, 22°C to 24°C (71.6°F-75.2°F). The doses of drugs and total volume of intraoperatively administered crystalloids were adjusted according to age, sex, body weight, and physical status of each patient and the duration of anesthesia. Blood loss was replaced with crystalloids at a 3:1 ratio or colloids at a 1:1 ratio. Urine output was replaced by crystalloids at a 1:1 ratio.

Because our objective was to measure the incidence of postoperative hypothermia in orthopedic patients in the PACU, we preferred not to alter the real conditions under which an orthopedic patient undergoes operation on an everyday basis in Greece. In the surgery department, we have 12 operating rooms and only 5 Bair-Hugger systems (Arizant Healthcare Inc, Eden Prairie, Minn), thus we cannot afford a Bair-Hugger system for each operating room. In the operating rooms, the only measure taken to prevent heat loss during the intraoperative period is covering patients with a simple sheet (or, rarely, with a reflective blanket). Thus, forced-air warming was not applied intraoperatively.

This study was approved by the Ethical Committee of the hospital. The interventions were restricted to observing, measuring, and recording vital parameters of the patients, whose anonymity and confidentiality were assured. With regard to the routine clinical practice in Greece, no part of the standard care of patients was omitted. After PACU arrival, convection warming therapy was applied to all patients who were hypothermic, and supplemental oxygen was administered by the use of simple or Venturi masks.

- Statistical analysis. The t test or \( \chi^2 \) test was used to compare and detect differences in the demographic data of hypothermic and normothermic patients or shivering and non–shivering patients. The \( \chi^2 \) test also was used to detect correlations between hypothermia and shivering.

With regard to standard PACU monitoring parameters, our aim was to determine whether heart rate, mean arterial blood pressure, and oxygen saturation were affected significantly by the presence of hypothermia or shivering on PACU arrival. In most patients during the perioperative period, core temperature begins to decrease after induction of anesthesia, either general or regional, due to disruption of the normal thermoregulatory mechanisms. Thus, until induction of anesthesia, standard PACU monitoring parameters cannot be affected by hypothermia or shivering, and, at this time point, values can be considered “normal.” Moreover, in most patients undergoing general anesthesia, core temperature stops decreasing after awakening from anesthesia as patients begin to regain normal thermoregulation. In our study, which included only extubated
patients, awakening from anesthesia coincided with the immediate postoperative period (PACU arrival). Similarly, in patients undergoing spinal anesthesia, the sympathetic block begins to fade after the end of the operation (duration of surgery is approximately known, so the doses of drugs can be adjusted properly). In most cases, shivering becomes present immediately after awakening from anesthesia. Standard PACU monitoring parameters can be well regulated during anesthesia through the continuous administration of volatile anesthetics or analgesic drugs. The possible impact of hypothermia or shivering becomes evident during the immediate postoperative period, when this regulation is impossible.

In surgical patients, many factors, such as pain, circulatory and respiratory problems, and drug administration, potentially may affect standard PACU monitoring parameters, so it is difficult to determine the exact alteration of vital signs attributed to hypothermia or shivering. The effects of these factors can be eliminated partially by comparing the monitoring parameters between hypothermic and normothermic patients (used as a control group) or between shivering and non–shivering patients (control group). Hypothermia and shivering (independent variables) were considered as the only different factors between the 2 groups (hypothermic and normothermic or shivering and non–shivering patients), whereas other factors, such as pain and drug administration, were distributed equally in both groups.

Moreover, preoperative values of monitoring parameters may differ significantly among patients. In our study, we used analysis of covariance to adjust for the preexisting values of monitoring parameters measured just before induction of anesthesia and considered to be the covariate variable and to remove their effects on PACU arrival monitoring parameters, which were the dependent variables. For all analyses, a P value of less than .05 was used to determine statistical significance.

**Results**

- **Hypothermia and shivering.** The total sample population included 170 patients: 67 men (39.4%) and 103 women (60.6%), 142 classified as ASA physical status 1 or 2 (83.5%) and 28 as ASA physical status 3 or 4 (16.5%). Of the patients, 113 received general anesthesia (66.5%) and 57 received regional anesthesia (33.5%). The mean ± SD age was 53.9 ± 16.6 years, mean ± SD total time in the operating room was 154.7 ± 25.8 minutes, and mean ± SD operating room temperature was 23.0°C ± 1.9°C (73.2°F ± 3.2°F).

Hypothermia was present in 125 patients (73.5%), with core temperatures ranging from 34.4°C to 35.9°C. Patient and operation characteristics between hypothermic and normothermic patients did not yield significant differences for age, sex, ASA classification, anesthetic technique, or operating room temperature (Table 1). The only parameter found to be significantly different was the total time in the operating room (P = .02).

Shivering was present in 42 patients (24.7%). Patient and operation characteristics between shivering and non–shivering patients did not yield significant differences for sex, ASA classification, anesthetic technique, total time in the operating room, or operating room temperature (Table 2). The only parameter found to be significantly different was age (P = .01).

At PACU arrival, 38 hypothermic and 4 normothermic patients developed shivering (Table 3). A significant correlation between hypothermia and shivering was noted in postoperative patients (P < .01).

- **Standard PACU monitoring** (Tables 4 and 5). The preoperative heart rate, mean arterial blood pressure, and oxygen saturation of arterial blood were comparable between hypothermic and normothermic

### Table 1. Differences between hypothermic and normothermic patients

<table>
<thead>
<tr>
<th></th>
<th>Hypothermic patients (n = 125)</th>
<th>Normothermic patients (n = 45)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>55.1 ± 15.4</td>
<td>50.5 ± 19.3</td>
<td>.11</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>51/74</td>
<td>16/29</td>
<td>.54</td>
</tr>
<tr>
<td>Anesthetic technique (general/regional)</td>
<td>85/40</td>
<td>28/17</td>
<td>.48</td>
</tr>
<tr>
<td>ASA classification (1-2/3-4)</td>
<td>103/22</td>
<td>39/6</td>
<td>.51</td>
</tr>
<tr>
<td>Total time in operating room (min)</td>
<td>157.5 ± 25.6</td>
<td>146.9 ± 25.0</td>
<td>.02</td>
</tr>
<tr>
<td>Operating room temperature (°C/°F)</td>
<td>22.8 ± 1.8/73.0 ± 3.2</td>
<td>23.1 ± 1.9/73.6 ± 3.4</td>
<td>.28</td>
</tr>
</tbody>
</table>

Data are presented as number or mean ± SD.
patients. After removing the covariance of preoperative values of monitoring parameters, only the mean arterial blood pressure was affected by hypothermia \((F = 5.248; P = .02)\), and only heart rate was affected by shivering \((F = 4.696; P = .03)\); oxygen saturation was affected by neither. Postoperative adjusted mean arterial blood pressure of hypothermic patients was significantly higher than that of normothermic patients \((\text{mean} \pm \text{SE}, 102.9 \pm 0.8 \text{ mm Hg vs } 97.6 \pm 1.2 \text{ mm Hg})\). The postoperative adjusted heart rate of shivering patients was significantly higher than that of non–shivering ones \((73.4 \pm 0.9 \text{ beats per minute vs } 68.5 \pm 1.4 \text{ beats per minute})\).

Discussion

• Hypothermia and shivering. The incidence of hypothermia in postoperative orthopedic patients was high, at 73.5%. Kean\(^34\) observed that orthopedic operating rooms had the lowest ambient temperatures, with orthopedic patients showing a high incidence of hypothermia. When no efficient preventive measures are taken during the operation, hypothermia occurs, even after minor surgical procedures.

Our findings confirm that postanesthetic shivering is, for the most part, thermoregulatory. However, it also was observed in normothermic patients, and this supports the hypothesis that other factors may cause non–thermoregulatory tremor. In the patients we studied, the incidence of this type of shivering was very rare, only 8.9%. Horn et al\(^25\) reported a relatively high incidence of shivering, 27%, in normothermic patients after major orthopedic surgery. Such differences observed between similar studies might be attributed to different patient characteristics in the studies.

The mean age of shivering patients was significantly younger, which is consistent with the findings of other studies.\(^11,35\) Advanced age impairs thermoregulatory responses, in the presence and absence of anesthesia. Ozaki et al\(^36\) showed a lower vasoconstriction threshold in older patients during general anesthesia. The shivering threshold also may be lowered with age.

• Standard PACU monitoring. In the present study, only mean arterial blood pressure was affected by hypothermia. Frank et al\(^30\) reported a lower heart rate and higher arterial blood pressures (systolic, mean, and diastolic) in hypothermic patients during the early postoperative period. However, they studied relatively old patients with 2 or more risk factors for coronary artery disease. Kurz et al\(^20\) studied young and healthy patients and found no difference in postoperative heart rate and arterial blood pressure between hypothermic and normothermic patients. Hypothermia may cause hypertension due to catecholamine action and vasoconstriction, but the degree of core temperature decrease, which is necessary for a significant increase in blood pressure, is not known.

### Table 2. Differences between shivering and non–shivering patients

<table>
<thead>
<tr>
<th></th>
<th>Shivering patients ((n = 42))</th>
<th>Non–shivering patients ((n = 128))</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>(48.4 \pm 14.2)</td>
<td>(55.7 \pm 16.9)</td>
<td>.01</td>
</tr>
<tr>
<td>Sex ((\text{M/F}))</td>
<td>16/26</td>
<td>51/77</td>
<td>.84</td>
</tr>
<tr>
<td>Anesthetic technique ((\text{general/regional}))</td>
<td>27/15</td>
<td>(86/42)</td>
<td>.73</td>
</tr>
<tr>
<td>ASA classification ((1-2/3-4))</td>
<td>38/4</td>
<td>104/24</td>
<td>.16</td>
</tr>
<tr>
<td>Total time in operating room ((\text{min}))</td>
<td>(160.5 \pm 27.0)</td>
<td>(152.8 \pm 25.2)</td>
<td>.09</td>
</tr>
<tr>
<td>Operating room temperature ((^\circ\text{C}^/\text{°F}))</td>
<td>(22.6 \pm 1.9/72.6 \pm 3.4)</td>
<td>(23.0 \pm 1.8/73.4 \pm 3.2)</td>
<td>.33</td>
</tr>
</tbody>
</table>

Data are presented as number or mean ± SD.

### Table 3. Hypothermia and shivering among patients in the postanesthesia care unit

<table>
<thead>
<tr>
<th></th>
<th>Shivering patients ((n = 42))</th>
<th>Non–shivering patients ((n = 128))</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothermic patients ((n = 125))</td>
<td>38 ((30.4%))</td>
<td>87 ((69.6%))</td>
<td>.01</td>
</tr>
<tr>
<td>Normothermic patients ((n = 45))</td>
<td>4 ((9%))</td>
<td>41 ((91%))</td>
<td></td>
</tr>
</tbody>
</table>

Data are presented as number (percentage).
In orthopedic patients, although the core temperature decrease was rather small, the mean arterial blood pressure was affected significantly. Heart rate was the only parameter affected by the presence of shivering. Heffline also reported a significant reduction in heart rate and arterial blood pressure at the end of shivering. It seems that, in combination with hypothermia, shivering possibly results in an increased metabolic rate, tachycardia, and increased cardiac output.

**• Implications for nursing practice.** Our results confirm that there is an imperative need for intraoperative forced-air warming of all patients, regardless of the type and duration of operation. The purchase and use of many forced-air warmers seems particularly expensive. However, as Augustine Medical has shown, because hypothermia increases indirect costs (length of PACU stay, nursing time, adverse events), the use of forced-air warming actually may reduce overall hospitalization costs.

Shivering usually comes as a result of postoperative hypothermia, so its primary treatment should involve rewarming. However, because other factors contribute to the manifestation of shivering, rewarming always should be combined with the intravenous administration of drugs. Opioids (morphine or meperidine) have suppressed shivering in 2 to 5 minutes. Nefopam, a new analgesic agent, can significantly reduce the shivering threshold without compromising ventilation, causing sedation, or altering the vasoconstriction threshold.

During anesthesia, there is a potential for continuous drug administration, such as volatile anesthetics (sevoflurane) and intravenous analgesics (remifentanil). These drugs offer us the advantage of continuous regulation of heart rate and arterial blood pressure, which can be maintained within narrow limits (according to the baseline values of each patient as measured before induction of anesthesia). After awakening from anesthesia, this regulation potential is lost, and standard PACU monitoring parameters can be affected by many factors and rapidly altered during the immediate postoperative period. It is important that PACU nurses are aware of the possible impact of hypothermia and shivering on the arterial blood pressure and heart rate, respectively. Immediate recognition and intervention are critically important in patients with chronic cardiovascular diseases because hemodynamic instability can lead to serious complications during the postoperative period (even life-threatening complications, such as myocardial ischemia).

**• Limitations.** Some, possibly inevitable, limitations of our study are the following: (1) The design was quasi-experimental. Subjects were not randomly allocated in 2 homogeneous groups but were divided

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### Table 4. Analysis of covariance of standard PACU monitoring parameters between hypothermic and normothermic patients (on PACU arrival)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hypothermic patients</th>
<th>Normothermic patients</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats/min)</td>
<td>70.4 ± 1.1</td>
<td>68.0 ± 1.5</td>
<td>1.269</td>
<td>.26</td>
</tr>
<tr>
<td>Mean arterial blood pressure (mm Hg)</td>
<td>102.9 ± 0.8</td>
<td>97.6 ± 1.2</td>
<td>5.248</td>
<td>.02</td>
</tr>
<tr>
<td>Oxygen saturation of arterial blood (%)</td>
<td>96.9 ± 0.3</td>
<td>97.2 ± 0.4</td>
<td>0.406</td>
<td>.52</td>
</tr>
</tbody>
</table>

PACU indicates postanesthesia care unit. Data are presented as postoperative adjusted (for preoperative values) mean ± SE.

### Table 5. Analysis of covariance of standard PACU monitoring parameters between shivering and non–shivering patients (on PACU arrival)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Shivering patients</th>
<th>Non–shivering patients</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats/min)</td>
<td>73.4 ± 0.9</td>
<td>68.5 ± 1.4</td>
<td>4.696</td>
<td>.03</td>
</tr>
<tr>
<td>Mean arterial blood pressure (mm Hg)</td>
<td>104.1 ± 0.7</td>
<td>100.7 ± 1.1</td>
<td>2.807</td>
<td>.09</td>
</tr>
<tr>
<td>Oxygen saturation of arterial blood (%)</td>
<td>96.5 ± 0.2</td>
<td>97.2 ± 0.3</td>
<td>1.385</td>
<td>.24</td>
</tr>
</tbody>
</table>

PACU indicates postanesthesia care unit. Data are presented as postoperative adjusted (for preoperative values) mean ± SE.
according to the presence of postoperative hypothermia or shivering. Thus, some patient characteristics differed between the 2 groups. Our assumption was that this difference was not clinically significant. (2) The study population was restricted to orthopedic patients, so our findings might not be generalizable to other categories of surgical patients. Recommended future research should focus on other populations of surgical patients. (3) This study focused on investigating whether standard PACU monitoring parameters were affected significantly in hypothermic or shivering patients on PACU arrival. Other researchers possibly may investigate the variation of these parameters until the reverse of hypothermia or the end of shivering.

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