MAJOR ARTICLE

Diagnostic Accuracy of Routine Postoperative Body Temperature Measurements

Hester Vermeulen,[1] Marja N. Storm-Versloot,[1] Astrid Goossens,[2] Peter Speelman,[3] and Dink A. Legemate[1]

Departments of [1]Surgery, [2]Clinical Epidemiology and Biostatistics, and [3]Internal Medicine, Academic Medical Center, University of Amsterdam, Amsterdam, The Netherlands

(See the editorial commentary by Dellinger on pages 1411–2)

Background. On surgical wards, body temperature is routinely measured, but there is no proof that this is useful for detecting postoperative infection. The aim of this study was to compare temperature measurements (the test) with the confirmed absence or presence of a postoperative infection (the reference standard).

Methods. A prospective triple-blinded diagnostic study involving 308 consecutive patients was performed. A positive test result was defined as a postoperative temperature ⩾38.0°C. The reference standard was considered to indicate a postoperative infection if results of a bacterial culture were positive or if an infection was suspected on clinical grounds.

Results. Data for 284 of 308 patients were analyzed (2282 temperature measurements). The prevalence of infection was 7% (19 of 284 patients). The temperature curves of patients were used as units of analysis and revealed that a temperature ⩾38.0°C had a sensitivity of 37% (95% confidence interval [CI], 0.16%–0.62%) and a specificity of 80% (95% CI, 0.75%–0.85%). The likelihood ratio for a positive test result was 1.8 (95% CI, 0.7–4.0) and for a negative test result was 0.8 (95% CI, 0.4–1.4). When all 2282 measurements were considered as independent test results, the positive predictive value was only 8% (95% CI, 5%–13%). Six of 8 patients with a severe infection had temperatures <38°C.

Conclusion. Routine measurement of body temperature is of limited value in the detection of infection after elective surgery for noninfectious conditions. Serious postoperative infections can even occur without an accompanying increase in temperature.

After surgical intervention, body temperature is measured daily during the postoperative period for the diagnostic detection or exclusion of infection. Physicians routinely request body temperature data during ward rounds and when patients develop postoperative problems, such as pulmonary insufficiency or abdominal symptoms. In practice, many physicians and nurses consider information about the body temperature to be essential to support their clinical judgment and confirm clinical signs of infection.

The few studies that have investigated the clinical value of postoperative temperature measurements seem to indicate that such measurements are not reliable diagnostic tools [1–5]. These studies have important methodological flaws, such as absence of blinding, use of surrogate end points, and use of retrospective study designs, which might be a reason that temperature measurement is still widely performed. Moreover, physicians are more likely to order the performance of additional diagnostic tests if fever is present and to consider an infection to be less probable if the body temperature is normal. The aim of our study was to prospectively assess the diagnostic accuracy of routine postoperative temperature measurements by comparing them with the presence or absence of postoperative infection in a general surgical population.

METHODS

Patients. During a 7-month period, all patients who were admitted to the general surgical wards at the Academic Medical Center of the University of Amsterdam and who were scheduled to undergo an elective operation were eligible for inclusion. Patients with an active infection at the time of the operation were not eligible,

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Reprints or correspondence: Prof. Dr. D. A. Legemate, G4-111, Academic Medical Center, Meibergdreef 9, 1105 AZ Amsterdam, The Netherlands (d.a.legemate@amc.uva.nl).

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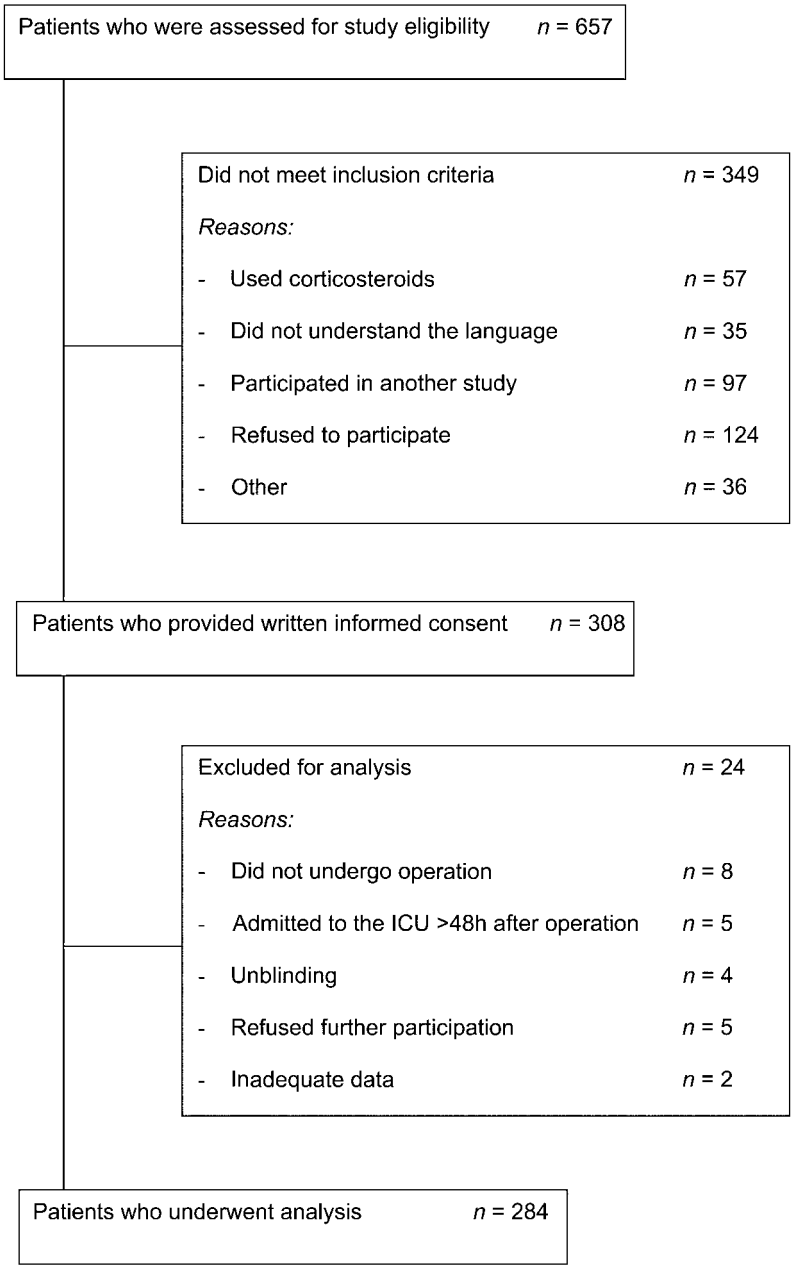

Figure 1. Patient flow through the phases of inclusion for the study. ICU, intensive care unit.

nor were those who used corticosteroids, did not understand the Dutch language, or were already enrolled in another study.

Patients participated up to the time of hospital discharge (for a maximum enrollment duration of 14 days) or until the end point was reached (i.e., the diagnosis of a postoperative infection according to the definitions of the reference standard). Patients admitted to the intensive care unit for >48 h after surgery were excluded from the analysis, because they are routinely given antibiotics for selective bowel decontamination. The medical ethics committee at the Academic Medical Center approved the study protocol; all patients gave written informed consent.

Definitions. In this blinded, prospective cohort study, the postoperative body temperature measurements were compared with the reference standard, which was the presence or absence of a postoperative infection (defined below). A positive test result was defined as a temperature ⩾38.0°C on at least 1 occasion in the patient's body temperature curve (unit of analysis, each temperature curve [$n = 284$]). A negative test result was defined as a temperature <38.0°C and >35.5°C. Additionally,

Table 1. Demographic characteristics of 284 patients enrolled in a study to analyze the diagnostic value of body temperature for determining infection after surgery.

Characteristic	Value
Age, mean years ± SD	55.3 ± 16.1
Male sex	134 (47)
Type of surgery	
General	75 (26.4)
Trauma	57 (20.1)
Vascular	47 (16.5)
Gastrointestinal	105 (37.0)
Duration of hospitalization after surgery, median days (range)	6.5 (1–59)
In-hospital mortality rate	2 (0.8)

NOTE. Data are no. (%) of patients, unless otherwise indicated.

temperature data were also analyzed as independent measurements (unit of analysis, each temperature measurement [$n = 2282$]).

The presence of a postoperative infection was defined as positive results of a bacterial culture of normally sterile body fluid, the performance of which was requested if the treating physician suspected an infection on the basis of information from the medical history, findings of physical and blood examinations, or findings of radiological investigation. This definition accords with that of the Centers for Disease Control and Prevention [6, 7]. If body fluid specimens could not be obtained for culture but infection was suspected and antibiotics were subsequently prescribed, the criterion standard was considered to be indicative of pulmonary infiltration (e.g., on the basis of radiographic evidence of pulmonary infiltration in or the presence of erysipelas on the wound). The absence of a postoperative infection was defined as a postoperative hospital period without any clinical signs of infection, with negative bacteriological cultures, and no prescription of antibiotics. Even if patients did not show any signs of infection during the first 14 postoperative days, their case notes up to the 17th postoperative day were checked to make sure no positive results of body fluid cultures had been returned after the 14th postoperative day. If a patient had been discharged within 14 days after the operation, follow-up ended on the day of discharge, and body temperature was no longer measured.

Temperature measurement and blinding. During the patients' stay in the operating theater, recovery room, or the intensive care unit, the outcome of the temperature measurement was not blinded. Blinding started when the patient was transported to the surgical ward. The study was triple blinded: neither the patient, the treating physicians, nor the nurses were informed about the outcome of the measurements. Twice per day, at intervals of no less than 8 h, independent nurses who were not involved in the routine care of the participants measured the participants' temperatures using an ear thermometer (First Temp Genius; Sherwood Medical). Unblinding was only possible if an infection was diagnosed according to the definitions of the criterion standard, if the temperature increased >1°C during blood transfusion, if a temperature of <35.5°C was recorded (because this was considered as a warning of sepsis), or if a rigor accompanied by a temperature ⩾39°C occurred. In these situations, the independent nurse was allowed to inform the nurse caring for the patient about the change in temperature.

Safety. An independent committee consisting of a surgeon, an internist, and a clinical epidemiologist monitored the safety of the study. As each 100 patients were recruited, the committee evaluated those who had developed a postoperative infection. They judged the extent, if any, to which there had been a delay in diagnosis or an unnecessary risk for the patient. The study would have been terminated if the committee concluded that there had been a delay of >3 days in treatment (as a result of blinding of the temperature data) that led to serious consequences for the patient, the definitions of which were left to the discretion of the committee.

Analysis. Predictive values for all measurements were cal-

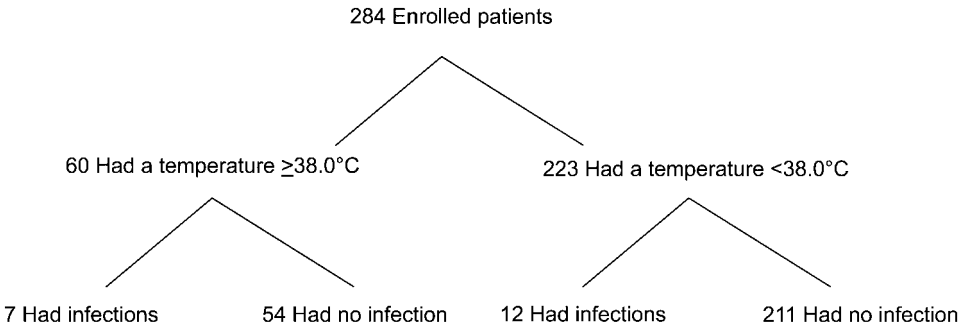

Figure 2. Frequency table of patients with and patients without a temperature increase (to ⩾38.0°C) on at least 1 occasion in their temperature curve and the presence or absence of a postoperative infection.

Table 2. Diagnostic characteristics of 3 cutoff body temperatures that were measured on at least 1 occasion in the temperature curve for 284 patients in a study to analyze the diagnostic value of body temperature for determining infection after surgery.

Diagnostic characteristic	Cutoff body temperature, value (95% CI)		
	⩾38.0°C	⩾38.5°C	⩾39.0°C
Sensitivity, %	37 (16–62)	5 (0–26)	0 (0–18)
Specificity, %	80 (75–85)	93 (89–95)	98 (96–99)
Positive predictive value, %	12 (5–22)	5 (0–24)	0 (0–52)
Negative predictive value, %	95 (91–97)	93 (89–96)	93 (90–96)
Positive likelihood ratio	1.8 (0.7–4.0)	0.7 (0–4.4)	0 (0–5.2)
Negative likelihood ratio	0.8 (0.4–1.4)	1.0 (0.6–1.7)	1 (0.6–16)

culated for cutoff points of 38.0°C, 38.5°C, and 39°C. Sensitivity, specificity, predictive values, and likelihood ratios were calculated for the same cutoff points using each patient's temperature curve as a unit of analysis (a positive test result was defined as a temperature ⩾38.0°C, ⩾38.5°C, or ⩾39°C measured on at least 1 occasion) and each temperature measurement as a unit of analysis. A positive likelihood ratio (i.e., a ratio ⩾1.0) was defined as the percentage of true-positive test results divided by the percentage of false-positive test results. A negative likelihood ratio was defined as the percentage of false-negative test results divided by the percentage of true-negative test results (i.e., a ratio < 1.0).

RESULTS

During the study period, 657 patients were scheduled for an elective operation. From this group, 308 (47%) gave written informed consent, and 24 were not included in the final analysis (figure 1). The final study sample comprised 284 patients (table 1). All patients received antibiotic prophylaxis perioperatively.

Details of the postoperative temperature curves for and the infection statuses of the 284 patients at a cutoff temperature ⩾38.0°C are shown in a frequency table (figure 2). Additional details for different cutoff temperatures are shown in table 2. The sensitivity of routine temperature measurements (an elevated temperature measured on at least 1 occasion) to detect a postoperative infection for a cutoff temperature ⩾38.0°C was only 37% (95% CI, 16%–62%; of 19 patients with a confirmed infection, 7 had at least 1 positive test result); the sensitivity was lower for higher cutoff temperatures. The positive predictive value was also low (12%; 95% CI, 5%–22%; of 61 patients with at least 1 positive test result, 7 had a confirmed infection), as was the likelihood ratio for a positive test result (1.8; 95% CI, 0.7–4.0).

The temperature was measured 2282 times for the 284 patients. A temperature of ⩾38°C was measured in 171 (7.5%) of 2282 cases, only 14 (8%) of which were associated with a confirmed infection (table 3). The positive predictive value (cutoff temperature, ⩾38°C) for all independent measurements was 8% (95% CI, 5%–13%; of 171 positive test results, 14 were associated with a confirmed infection) (table 4). The negative predictive value was high. Details for different cutoff points are shown in tables 3 and 4.

Post hoc, we decided to also perform an analysis of patients for whom a body temperature ⩾38°C was measured at least on 2 consecutive occasions, as this is more convincing for the presence of an infection than just a single elevation in temperature. A total of 24 patients met this definition, 22 of whom did not have confirmed infection, resulting in a sensitivity of 11% (95% CI, 1%–33%; of 24 positive test results, 2 were associated with a confirmed infection) and a positive predictive value of 8% (95% CI, 1%–27%; of 19 confirmed infections, 2 were associated with a positive test result).

Sixty-one patients (21%) had a temperature that increased to ⩾38°C on at least 1 occasion (table 3). Of these, 24 (39%) had 2 consecutive temperature measurements of ⩾38°C. A temperature ⩾38°C was most often measured on the first or second postoperative day (76 of 171 measurements). During the first evening after surgery, the mean temperature (±SD) was 37.3°C ± 0.61°C; the mean temperatures on all postoperative days were 36.9°C–37.3°C.

The flow of participants during each stage is presented in

Table 3. Results of 2282 body temperature measurements for 284 patients in a study to analyze the diagnostic value of body temperature for determining infection after surgery.

Body temperature	No. of measurements		
	Associated with infection	Not associated with infection	Total
⩾39.0°C	0	5	5
⩾38.5°C to <39.0°C	1	34	35
⩾38.0°C to <38.5°C	13	118	131
<38.0°C	212	1899	2111
Total	226	2056	2282

Table 4. Diagnostic characteristics of 2282 individual body temperature measurements for 284 patients in a study to analyze the diagnostic value of body temperature for determining infection after surgery.

Diagnostic characteristic	Cutoff body temperature, value (95% CI)		
	⩾38.0°C	⩾38.5°C	⩾39.0°C
Positive predictive value, %	8 (5–13)	3 (0–13)	0 (0–52)
Negative predictive value, %	90 (89–91)	90 (89–91)	93 (89–91)

figure 1. A total of 24 patients were excluded from analysis because of the study protocol. In 4 of these patients, surgical trainees suspected an infection, and they unblinded the patients' temperature. In 2, a pulmonary infection was demonstrated by radiological investigation and was treated with antibiotics.

On the basis of clinical judgment, an infection was suspected in 30 (10.6%) of 284 patients, and additional tests were requested. In 19 (7%), a postoperative infection (as defined by the reference standard) was detected 1–12 days (median, 6 days) after the operation. Fourteen of the 19 infections were proven on the basis of positive results of a bacterial culture. In the other 5 patients, a diagnosis of infection was based on medical history, physical examination findings, or laboratory and/or radiological examination findings (3 had urinary tract infection, 1 had phlegmone of the wound, and 1 had pulmonary infection), and antibiotics were subsequently prescribed (table 5). The members of the safety committee concluded that there had been no delay in treatment as a result of blinding for these 19 patients.

Among the 19 patients, 8 developed a severe infection (4 had pulmonary infection, 3 had intra-abdominal infection, and 1 had *Escherichia coli* sepsis of unknown origin). Six of these 8 patients did not have a temperature ⩾38°C before the infection was diagnosed (table 5). The 3 patients with intra-abdominal infections (which were due to a perforation of the rectum 1 day after resection of a villous adenoma, leakage of a pancreaticojejunostomy after a Whipple operation, and leakage of an anastamosis after hemicolectomy) all required relaparotomy. Of the 7 patients with an infection accompanied by a positive test result, only the patient with *E. coli* sepsis had a temperature ⩾38.5°C (table 5). This patient's increase in temperature was measured on the first postoperative day. Positive results of cultures of a urine specimen, a blood specimen, and the tip of a deep venous catheter were used to confirm the diagnosis of *E. coli* sepsis. The source of infection became clear on day 10 after the operation, with the spontaneous perforation of an enterocutaneous fistula. CT findings were of no help for diagnosing the etiology of the sepsis.

DISCUSSION

Our diagnostic study demonstrates that routine postoperative temperature measurement is of limited value in the early detection or diagnostic exclusion of an infection after elective surgery. A considerable number of false-negative and false-positive test results resulted in a very low sensitivity, a low positive predictive value, and meaningless likelihood ratios. Moreover, our data demonstrate that routine temperature measurements may even mislead nurses and physicians. For example, if an infection develops with no accompanying increase in temperature, this might result in a delay in diagnosis and, subsequently, a delay in treatment. Six of 8 patients did not develop a temperature ⩾38.0°C despite having a very serious infection. In contrast, a patient with an increase in temperature but no infection may be subjected to additional and unnecessary testing to disclose a possible source of infection. However, because this was a triple-blind study, we were not able to

Table 5. Body temperatures of patients with confirmed postoperative infection in a study to analyze the diagnostic value of body temperature for determining infection after surgery.

Postoperative infection	No. (%) of patients with infection (n = 284)					
		By body temperature			By method of infection confirmation	
	Overall	<38.0°C	⩾38.0°C to <38.5°C	⩾38.5°C	Culture[a]	Judgment[b]
Pulmonary	4 (1.4)	3	1	…	3	1
Intra-abdominal	3 (1.1)	3	…	…	3	0
Wound	4 (1.4)	2	2	…	3	1
Urinary tract	7 (2.5)	4	3	…	4	3
Escherichia coli sepsis	1 (0.3)	…	…	1	1	0
Total	19 (6.7)	12	6	1	14	5

[a] Performed using normally sterile body fluid.
[b] Made on the basis of medical history, physical examination, and laboratory and/or radiological examination.

assess any delays in treatment or unnecessary requests for additional tests.

We postulated that an elevated body temperature measured on 2 consecutive occasions would serve as a better predictor of infection and would thus reduce false-positive test results. This proved not to be the case, because the sensitivity and positive predictive value were still extremely low.

We realize that information about body temperature is only 1 test in the diagnostic armamentarium of physicians and nurses and that the medical history and a physical examination of the patient can give important information about the patients' condition and might help to detect a possible infection. However, physicians still routinely request the body temperature during ward rounds and when patients develop postoperative problems, such as pulmonary insufficiency or abdominal symptoms. In practice, many physicians and nurses consider information about the body temperature to be essential to support their clinical judgment and confirm clinical signs of infection. We also found that patients rely heavily on information about their temperature. This was reflected in the high percentage of patients who refused to participate in the study because they thought that the blinding of routine temperature measurement would be harmful. We decided to exclude patients taking corticosteroids, because these agents can mask the symptoms of infection. At the end of the study, we concluded that routine measurements for these patients are also probably of limited value.

In our study, we used an ear thermometer. Several studies have demonstrated the reliability of the ear thermometer [8–10], although some authors have argued that it may register the temperature as being lower than it actually is [8, 9]. In a recently published systematic review comparing infrared ear thermometry with rectal thermometry in children, Craig et al. [11] concluded that ear thermometry is not as accurate as rectal thermometry. It should be noted that many different types of ear and rectal thermometers were used in these studies, which might have influenced the results. In our study, we used 1 type of ear thermometer, and the same nurses measured temperatures in accordance with standard procedures. Moreover, ear thermometry is currently accepted as the standard technique in many hospitals and thus reflects daily practice.

The median hospital stay was 6.5 days. Our study focused on events during the initial 14 days after operation. According to the design of the study, patients were not observed after hospital discharge. Therefore, we might have missed some infections that occurred after discharge in patients with a short hospital stay. This is likely a study limitation, although we have no reason to assume that this would have changed the conclusions of the study.

This study was performed as part of a continuing program for the development of clinical guidelines in our hospital. One of the essential elements in this program is the formulation of a study design that delivers evidence-based guidelines. On the basis of the results of this study and the associated possible harms, our advice is to abandon routine postoperative temperature measurements for patients who have undergone operations for the treatment of noninfectious conditions and to perform these measurements only when indicated.

Finally, we would like to stress that we have no reason to assume that our results are only applicable to the wide spectrum of procedures that patients undergo during general surgery. We believe that the results of this study can be extrapolated to other surgical specializations.

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The author contributions are as follows: H. Vermeulen contributed substantially to the conception and design of the study, the acquisition of data, and the analysis and interpretation of data; drafted the article; and gave final approval of the version to be published. M. N. Storm-Versloot contributed substantially to the conception and design of the study, the acquisition of data, and the analysis and interpretation of data and gave final approval of the version to be published. A. Goossens contributed substantially to the conception and design of the study and the interpretation of data, critically revised the drafted article for important intellectual content, and gave final approval of the version to be published. P. Speelman contributed substantially to the conception and design of the study, critically revised the drafted article for important intellectual content, and gave final approval of the version to be published. D. A. Legemate obtained funding, contributed substantially to the conception and design of the study and the interpretation of data, critically revised the drafted article for important intellectual content, and gave final approval of the version to be published.

All authors had access to all data in the study, and all held final responsibility for the decision to submit results for publication.

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Potential conflicts of interest. All authors: no conflicts.

References

1. Freischlag J, Busuttil RW. The value of postoperative fever evaluation. Surgery **1983**; 94:358–63.
2. Wilson AP, Treasure T, Gruneberg RN, Sturridge MF, Burridge J. Should the temperature chart influence management in cardiac operations? Result of a prospective study in 314 patients. J Thorac Cardiovasc Surg **1988**; 96:518–23.
3. Roberts J, Barnes W, Pennock M, Browne G. Diagnostic accuracy of fever as a measure of postoperative pulmonary complications. Heart Lung **1988**; 17:166–70.
4. Yeung RS, Buck JR, Filler RM. The significance of fever following operations in children. J Pediatr Surg **1982**; 17:347–9.
5. Bell DM, Goldmann DA, Hopkins CC, Karchmer AW, Moellering RC Jr. Unreliability of fever and leukocytosis in the diagnosis of infection after cardiac valve surgery. J Thorac Cardiovasc Surg **1978**; 75:87–90.
6. Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. Am J Infect Control **1992**; 20:271–4.
7. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC defi-

nitions for nosocomial infections, 1988. Am J Infect Control **1988**; 16: 128–40 (erratum: Am J Infect Control 1988; 16:177).
8. Rotello LC, Crawford L, Terndrup TE. Comparison of infrared ear thermometer derived and equilibrated rectal temperatures in estimating pulmonary artery temperatures. Crit Care Med **1996**; 24:1501–6.
9. Gimbel HM, Philipsen JP. Measurement of the ear temperature at a department of surgery [in Danish]. Ugeskr Laeger **1996**; 158:168–71.
10. Schmitz T, Bair N, Falk M, Levine C. A comparison of five methods of temperature measurement in febrile intensive care patients. Am J Crit Care **1995**; 4:286–92.
11. Craig JV, Lancaster GA, Taylor S, Williamson PR, Smyth RL. Infrared ear thermometry compared with rectal thermometry in children: a systematic review. Lancet **2002**; 360:603.