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Postoperative hypothermia: predictors and outcome. An observational study in a central hospital.

Mestrado Integrado em Medicina

Área: Anestesiologia

Trabalho efetuado sob a Orientação de:
Professor Doutor Fernando Abelha

Trabalho organizado de acordo com as normas da revista:
European Journal of Anaesthesiology

março, 2012

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Número do Bilhete de Identidade: 11914999

Título da Dissertação:

Postoperative hypothermia: predictors and outcome. An observational study in a central hospital.

Orientador:

Fernando José Pereira Alves Abelha

Ano de conclusão: 2012

Designação da área do projeto:

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Assinatura: Rosália Cristina Gabriel Páscoa

Postoperative hypothermia: predictors and outcome. An observational study in a central hospital.

Postoperative hypothermia, an observational study.

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Context: Inadvertent postoperative hypothermia is known to be associated with various adverse physiologic effects and is a problem with high incidence.

Objective(s): The aim of this study was to estimate the incidence, predictors and outcome of core hypothermia on admission at post-anesthesia care unit.

Design: Observational, prospective study.

Setting: Post-anesthesia care unit of a tertiary hospital: Centro Hospitalar São João, Porto, Portugal. During the period of 9 to 27 May 2011.

Patients: 357 patients were admitted and 340 eligible for this study. A written informed consent was obtained before surgery. Exclusion criteria were defined as: age under 18 years; inability to provide informed consent; patient refusal; foreign nationals; urgent/emergent/cardiac surgery; neurosurgery or others procedures need to undertake therapeutic hypothermia and known neuromuscular disease.

Main outcome measures: Mini-mental state examination, vital signs, perioperative variables.

Results: Incidence of hypothermia on admission was 32.4%. Hypothermia was neither a risk factor for hospital mortality nor a predictor for longer hospital stay but was for longer length of post-anesthesia care unit stay. In univariate analysis: age ≥65 (42% *versus* 30%, p=0.025), body mass index (25.9 ± 5.0 *versus* 27.8 ± 5.9, p=0.001), high risk surgery (35% *versus* 24%, p=0.040), revised cardiac risk index >2 (8% *versus* 3%, p=0.019), general anesthesia (72% *versus* 13% for locorregional, p=0.016), forced-air warming technic (42% *versus* 28%, p=0.013), intravenous crystalloids administrated (median of 1.724 *versus* 1.236 liters, p<0.001), fasting times (14.0 ± 3.8 *versus* 15.0 ± 4.0 hours, p=0.025), duration of anesthesia (median of 150 min. *versus* 102 min., p<0.001) and of surgery (median of 110 *versus* 70 min., p<0.001) and visual analogue scale of pain >3 (median of 2.5 *versus* 1.0, p= 0.031), were considered predictors of hypothermia. In multiple logistic regression analysis, low body mass index, higher scores in revised cardiac risk index, longer duration of anesthesia and higher scores in visual analogue scale of pain were considered independent predictors of hypothermia.

Conclusions: Although the adverse effects of inadvertent hypothermia are well known, incidence remains high. Awareness of this fact is critical to its prevention.

Key words: core temperature; inadvertent postoperative hypothermia; incidence; predictors; outcome; post-anesthesia care unit.

Introduction

Hypothermia is defined as core body temperature less than 36.0ºC, although some studies has considered lower limits because of a high incidence of patients bellow 36 ºC and for statistical analyses.[1,2,3] Inadvertent postoperative hypothermia (IPH) emerges as the most common thermic alteration associated with anesthesia and surgery.[4] Despite of core temperature (Tc) normally be tightly controlled in human beings,[5,6] general anesthesia significantly impairs the thermoregulatory system; and the same happens with neuraxial (spinal and epidural) anesthesia, even with a potential lesser extent. The result is that un-warmed surgical patients almost inevitably become hypothermic.[7] IPH is a recognized side-effect of general and regional anesthesia, once normal thermoregulation is inhibited[3] but Tc is seldom monitored in clinical practice.[8]

IPH is known to be associated with various adverse physiologic effects.[1,9,10] Hypothermia alters the normal physiology of most body systems and therefore will also be altered pharmacokinetics and pharmacodynamics of drugs during this state.[2,11] Core hypothermia may explain situations as broad as: adverse myocardial outcomes in high-risk patients, significantly augment of blood transfusion and surgical wound infection,[8,11,12,13] delayed post anesthetic recovery,[12] postoperative negative nitrogen balance,[6] increased mortality in elderly patients with sepsis,[14] and, with questionable clinical significance, alterations on pulse oximetry monitoring and on various electrophysiological indices of nervous system.[2]

Result of an altered distribution of body heat, rather than an imbalance between production and heat loss,[4] hypothermia appears when warming techniques are insufficient to counteract thermal redistribution resulting from the ablation of thermoregulatory vasoconstriction associated with anaesthesia.[15]

Several risk factors are described in literature for the development of IPH. The age (advanced), sex, body mass index (BMI) (low) and body surface area, preoperative body temperature, history of diabetic neuropathy, emergency surgery, American Society of Anesthesiology (ASA) physical status, surgical procedure in which major body cavities or major vessels are exposed, anesthetic technique, warming method, amount and temperature of intravenous replacement, duration of anesthesia or surgery and ambient operating room temperature are the risk factors that gather more consensus.[1,3,12,16] Risk factors are not independent and combinations of risk factors may be significant. It may also be important to distinguish between factors that make the patient more likely to become hypothermic, and those that place the patient at greater risk of prolonged hypothermia and/or at greater risk of complications from hypothermia because of their inability to recover from the hypothermic state.[3]

Although risk factors are identified, it is thought that perhaps these can be optimized in order to practice a more effective reduction in the incidence of core hypothermia on admission at post-anesthesia care unit (PACU).[1]

The aim of this study was to estimate the incidence, predictors and outcome of core hypothermia on admission at PACU.

Methods

The approval for this study was provided by the Ethics Committee of Centro Hospitalar São João, Porto, Portugal (Chairperson Prof. Dr. Filipe N. A. S. Almeida) on April 2011. This observational and prospective study was developed in the PACU of this central hospital during the period of 9 to 27 May 2011. Of all the participants (340 patients: table 1 and 2) was obtained a written informed consent, according to this particular model work, before surgery.

Exclusion criteria were defined as: age under 18 years; inability to provide informed consent or a score of < 25 in the mini-mental state examination (MMSE); patient refusal; foreign nationals; urgent/emergent surgery; cardiac surgery; neurosurgery or others procedures need to undertake therapeutic hypothermia and known neuromuscular disease.

In addition to informed consent, during the preoperative period, it was performed the MMSE.[17] Were also collected data, to a standardized data collection sheet, of the following clinical variables: age, gender, height, weight, ASA physical status, type of surgery, pre-existing medical conditions, preoperative medications and an extensive check-list for cardiac risk for Revised Cardiac Risk Index (RCRI) assessment according to the instructions from authors.[18] During the intraoperative period were recorded data for: type of anesthesia (general/loco regional/combined); duration of anesthesia and surgical time; intravenous administered fluids; type of active warming during the surgery; neuromuscular block; time of last dose of relaxant and use of neuromuscular block reversal drugs. Postoperatively, vital signs and mean *train-of-four* (TOF) were recorded, as well as, length of PACU stay.

For the study of hypothermia, Tc was evaluated by an infrared tympanic membrane thermometer (Thermos Scan® Type 6014 Pro 3000, Welch Allyn, with an accuracy of ± 0.03ºC in the range of 20ºC-42.2ºC – Welch Allyn Medical Products, NY, USA). This instrument was maintained and calibrated in accordance with the manufacturer's guidelines.

Patients were classified as hypothermic (Tc <35ºC) or normothermic (Tc ≥35ºC).

For the statistical analyses, ordinal and continuous data found not to follow a normal distribution, based on the Kolmogorov-Smimov test for normality of the underlying population, are presented as median and interquartile range. Normally distributed data are presented as mean and standard deviation (SD).

To identify predictors of hypothermia univariate analyses were performed using non parametric tests and Chi-square to compare groups. A multiple logistic regression analysis with an odds ratio (OR) and 95% confidence interval (CI) was performed to evaluate independent predictors of hypothermia.

All variables were deemed to be significant if $p \leq 0.05$. Data were analyzed using SPSS for Windows version 16.0 (SPSS, Chicago, IL).

Results

Of a total of 357 patients, 340 were included in the study (table 1 and 2), 17 patients were excluded: 7 patients were admitted in a surgical intensive care unit, 3 patients were incapable of providing informed consent or had a MMSE < 25, 3 patients were not submitted to surgery, 1 patient was excluded because was submitted to a neurosurgery, 1 was less than 18 years old, 1 did not speak Portuguese and 1 refused to participate.

The mean (± SD) admission Tc was 35.3ºC ± 0.7ºC (interquartile range, 34.9ºC-35.7ºC); 32.6ºC was the lowest temperature registered and 37.5ºC the maximum. Incidence of core hypothermia on the admission at PACU was 32.4% (110 patients). 85.9% of patients had less than 36.0ºC.

Patients with hypothermia (table 3 and 4) had more frequently age ≥65 years (42% *versus* 30%, p=0.025) had lower body mass index (25.9 ± 5.0 *versus* 27.8 ± 5.9, p=0.001), were more frequently submitted to high risk surgery (35% *versus* 24%, p=0.040), had higher scores in RCRI (RCRI >2, 8% *versus* 3%, p=0.019), had more frequently general anesthesia as a unique technic (72% *versus* 13% for locorregional, p=0.016) and more frequently used a forced-air warming technic (42% *versus* 28%, p=0.013). The total amount of intravenous crystalloids administrated were higher (median of 1.724 *versus* 1.236 L., p<0.001) and they had shorter fasting times (14.0 ± 3.8 *versus* 15.0 ± 4.0 hours, p=0.025), longer duration of anesthesia (median of 150 *versus* 102 min., p<0.001) and of surgery (median of 110 *versus* 70 min., p<0.001) and they presented higher scores for visual analogue scale of pain (VAS >3, median of 2.5 *versus* 1.0, p=0.031). Hypothermia was neither a risk factor for hospital mortality nor a predictor for longer hospital permanence but was for longer length post-anesthesia care unit stay (median 106 *versus* 90 min., p=0.009).

In multiple logistic regression analysis (table 5), independent predictors of hypothermia were: BMI (OR 0.93, 95% CI, 0.89-0.98, p=0.006), RCRI >2 (OR 3.40, 95% CI, 1.13-10.2, p=0.029), duration of anesthesia (OR 1.52, 95% CI, 1.27-1.83, p<0.001), and VAS pain at PACU admission (OR 1.74, 95% CI, 1.05-2.87, p=0.031).

The assessment of vital signs (table 6) showed that were no statistically significant differences between patients with hypothermia *versus* normothermia, except with regard to pain evaluation at PACU admission.

During our study, 2 participants died. One of them was hypothermic and the other not, and no statistical inferences were made.

Discussion

The incidence of hypothermia at PACU admission was higher than other studies that have considered the same cut-off of 35ºC to define hypothermia.[1,12,19] In a previous published study, performed in the same Department, authors' found a higher incidence, but the studied cohort was composed of critical care surgical patients.[12]

The use of infrared tympanic thermometers to measure patient's temperatures has been referred as a potential limitation for temperature evaluation.[1,12,20] Nierman found that comparing the 'gold standard' of a thermistor in a pulmonary artery catheter[21] to infrared tympanic, the tympanic thermometer present a bias (mean difference) of 0.1–0.4% less than thermistors, situation that could overestimate hypothermia, when the measurement is made by tympanic thermometers.[19] Therefore, considering the greatest reported bias, the real incidence of hypothermia in our study could have been slightly lower. About this matter, Sessler stated that when infrared signals are obtained exactly from the tympanic membrane, the result is real Tc. The limitation that Sessler recognizes to this type of evaluation is that there are infrared systems that, for its size, do not allows to reach the tympanic membrane and therefore are used only in aural canal performing an insufficiently accurate measure for clinical use.[7]

The strongest independent predictor of hypothermia we found was the RCRI >2. There is also a significant, but not independent, positive risk relation between hypothermia and the utilization of general anesthesia performed as a single technic, compared to locorregional anesthesia; general anesthesia technic is usually referred as a risk factor for hypothermia.[12] In fact, the process of heat redistribution during neuraxial anesthesia is different, once it is generally restricted to the lower body. Thus, redistribution decreases Tc about half as much when compared with other anesthesia technic but, constriction in legs is blocked peripherally, which means that for patients with long neuraxial anesthetic times, there is the potential of serious hypothermia.[3] And some evidence shows that passive thermal insulation of the patients did not minimize intraoperative hypothermia during spinal anesthesia.[22] Neuraxial anesthesia is often supplemented with sedatives and analgesics that impair thermoregulatory control even further.[23]

Similarly to other studies, this study identified as risk factors for hypothermia at PACU admission, among others: advanced age,[1,12] the use of large amounts of intravenous fluids, duration of surgery or anesthesia[12]and high risk surgery.[24]

National Institute for Health and Clinical Excellence (NICE), assume that age is not an important risk factor for the incidence of hypothermia, either intra or postoperatively, although the data on Tc suggests that older people (over 60 years) have lower temperatures after 3 hours of surgery and at PACU arrival; besides, some consequences of hypothermia are more severe for older people, especially morbid cardiac events.[3]

As regards to intravenous fluids, if warmed (38-40ºC) to a temperature higher than operating room's there is a proved beneficial to patients in terms of hemodynamic stability, and for the development of a higher Tc.[22]

According to Putzu et al,[8] independently of anesthesia technic surgical patients always develop perioperative hypothermia when surgical procedure lasts more than 30 minutes. This is in agreement with our study, and others, which found that duration of anesthesia or surgery, are risk factors for hypothermia.[1]

For the result found for VAS >3, we can speculate whether it is pain that increases the incidence of hypothermia or if hypothermia leads to more pain postoperatively. Although, Persson *et al* in their study, conclude that there were no postoperative differences in analgesic requirements or pain intensity between normothermic and hypothermic patients.[25]

In our study, from the statistical point of view, the use of warming methods was not a protective factor as previously reported.[1,26,27] It should be noted, that these studies referred other warming methods than those used in our study, specifically to heat the entire operating theater. Besides, an OR of 1.84 for the use of warming methods could be explained by the fact that these warming methods are used more frequently in surgical procedures and in patients with an increased risk *ad initio*. It is noteworthy that preoperative skin surface warming, for an average of 72 min, reduced the impact of core-periphery temperature redistribution without significantly elevating preoperative Tc and decreases the incidence of IPH.[15]

Hart *et al*[22], cites Sessler stating that forced air warmers are one of the most effective means of warming a patient. These warmers work better intraoperatively when the patient's periphery is vasodilated. Without pre-warming, however, intraoperative warming techniques, including those employing forced air warming, still fail to eliminate the initial fall in temperature.[28]Although, extra warming with forced air (compared to routine thermal care) was effective in reduce incidence of surgical wound infections and postoperative cardiac complications. There are significant benefits associated with forced-air warming.[22]

In our study, we did not found a relationship between ASA physical status and core hypothermia**.** Although, others have claimed that ASA grade greater than ASA I is a risk factor for perioperative hypothermia, and that the risk increases with ASA grade.[3]

Of the variables considered in this study, the BMI was a protective variable for core hypothermia, similarly to what has already been indicated by other studies.[1] NICE admitted that increased body weight may have a small protective effect on the incidence of perioperative hypothermia in PACU, but the evidence for body weight and body fat in thermic regulation is inconsistent.[3]

In conclusion, although the adverse effects of hypothermia in surgical patients are well known, incidence remains higher than desirable. Awareness of this fact and of the predictors of perioperative hypothermia is critical to its prevention and to optimize clinical care provided to patients.

Conflicts of interest and sources of funding

The authors declare that they have no competing interests.

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Table 1. Preoperative characteristics of patients (n= 340)

Variable	Mean ± SD, median and P25-P75 or number (%)
Age	Median 57 (44-6), mean 55.6 ± 16.0
< 65 / ≥65 years	226 (67) / 114 (34)
Male / Female	146 (43) / 194 (57)
Body mass index (Kg/m²)	27.2 ± 5.7/ 26 (23-30)
ASA physical status	
I/II	277 (82)
III/IV/V	63 (19)
High risk surgery	93 (27)
Heart disease	
Ischemic	21 (6)
Congestive	20 (6)
Cerebrovascular disease	9 (3)
Insulintherapy for diabetes	49 (14)
Preoperative serum creatinine >2 mg/dl	17 (5)
RCRI	
≤2	326 (96)
>2	15 (4)
COPD	19 (6)
Hypertension	141 (42)
Hyperlipidemia	92 (27)

SD, Standart deviation; P25 and P75, 25th and 75th percentiles; ASA, American Society of Anesthesiologists; RCRI, Revised Cardiac Risk Index; COPD, Chronic obstructive pulmonary disease.

Table 2. Perioperative characteristics of patients (n=340)

Variable	Mean ± SD, median and P25-P75 or number (%)
Magnitude of surgery	
Minor	35 (10)
Medium	213 (63)
Major	34 (10)
Surgical risk	
Minor	74 (22)
Medium	232 (68)
Major	34 (10)
Type of anesthesia	
General	231 (68)
Regional	69 (20)
Combined	30 (9)
Sedation/analgesia	10 (3)
Warming methods	116 (34)
Fluids	24 (7)
Forced-air warming technic	111 (33)
Intraoperative fluids	
Intravenous crystalloids (L.)	1,394 ± 1,045 (1,000-1,875)
Intravenous colloids (L.)	25.0 ± 128 (0-0)
Packed erythrocytes (Units)	8.8 ± 53.6 (0-0)
Fresh frozen plasma (Units)	0 ± 0 (0-0)
Duration of anesthesia (min.)	134 ± 79 / 120 (71-180)
Duration of surgery (min.)	99 ± 67 / 80 (50-130)
Temperature on admission	35.3 ± 0.7 /35.3 (34.9-35.7)
<35ºC	110 (32)
Length of PACU stay (hours)	116 ± 92/ 95 (65-130)
Length of Hospital stay (days)	8 ± 13 / 2 (4-7)

SD, Standart deviation; P25 and P75, 25th and 75th percentiles; PACU, Postoperative Anesthesia Care Unit.

Table 3. Analysis of categorical and continuous preoperative variables of core hypothermia

Variable	**> 35ºC**	**≤ 35ºC**	**p-value**
Age	54.6 ± 15.6 / 56 (44-66)	57.7 ± 16.7 / 60 (47-71)	0.053
< 65 / ≥65	**162 (70) / 68 (30)**	**64 (58) /46 (42)**	**0.025**
Male / Female	91 (40) / 139 (60)	55 (50) / 55 (50)	0.069
Body Mass Index (Kg/m^2)	**27.8 ± 5.9 / 27 (24-31)**	**25.9 ± 5.0 / 27 (22-28)**	**0.001**
ASA physical status			0.854
I/II	188 (82)	89 (81)	
III/IV/V	42 (18)	21 (19)	
High risk surgery	**55 (24)**	**38 (35)**	**0.040**
Heart disease			
Ischemic	11 (5)	10 (9)	0.123
Congestive	11 (5)	9 (8)	0.213
Cerebrovascular disease	7 (3)	2 (2)	0.510
Insulintherapy for diabetes	36 (16)	13 (12)	0.346
Preop. serum creatinine>2 mg/dl	9 (4)	8 (7)	0.184
RCRI			**0.019**
≤2	224 (97)	102 (93)	
>2	6 (3)	9 (8)	
Hypertension	96 (42)	45 (41)	0.884
Hyperlipidemia	64 (28)	28 (26)	0.646
COPD	12 (5)	7 (6)	0.667

SD, Standart deviation; P25 and P75, 25th and 75th percentiles; ASA, American Society of Anesthesiologists; RCRI, Revised Cardiac Risk Index; COPD, Chronic obstructive pulmonary disease.

Table 4. Analysis of categorical and continuous perioperative variables of core hypothermia

Variable	> 35ºC	≤ 35ºC	*p-value*
Magnitude of surgery			0.162
Minor	24 (10)	11 (10)	
Medium	151 (66)	62 (56)	
Major	55 (24)	37 (34)	
Surgical risk			0.106
Minor	57 (25)	17 (16)	
Medium	153 (66)	79 (72)	
Major	20 (9)	14 (13)	
Type of anesthesia			**0.016**
General	152 (66)	**79 (72)**	
Locoregional	55 (24)	**14 (13)**	
Combined	17 (7)	15 (14)	
Sedation/analgesia	8 (4)	2 (2)	
Warming methods	**62 (28)**	**48 (41)**	**0.010**
Fluids	17 (7)	7 (6)	0.729
Forced-air warming technic	**65 (28)**	**46 (42)**	**0.013**
Intraop fluids			
Intravenous crystalloids (L.)	**1.236 ± 0.910 (1.000-1.125)**	**1.724 ± 1.246 (1.000-2.380)**	**< 0.001**
Intravenous colloids (L.)	17.4 ± 103.0 (0-0)	40.9 ± 167.7 (0-0)	0.147
Packed erythrocytes (Units)	6.5 ± 39.9 (0-0)	13.6 ± 74.5 (0-0)	0.584
Fresh frozen plasma (Units)	0 ± 0 (0-0)	0 ± 0 (0-0)	1
Fasting (hours)	**15.0 ± 4.0**	**14.0 ± 3.8**	**0.025**
Duration of anesthesia (min.)	**120 ± 75 / 102 (60-150)**	**163 ± 81 / 150 (99-210)**	**<0.001**
Duration of surgery (min.)	**88 ± 63 / 70 (40-120)**	**120 ± 69 / 110 (60-162)**	**<0.001**
Tc admission <35ºC	35.6 ± 0.4 / 35.6 (35.3-35.9)	34.6 ± 0.5 / 34.6 (34.4-34.9)	
Length of PACU stay (min.)	**106 ± 92 / 90 (65-125)**	**137 ± 121 / 106 (75-147)**	**0.009**
Length of Hospital stay (days)	7.2 ± 12.0 / 4 (2-7)	8.3 ± 14.1 / 5 (2-8)	0.167
VAS >3	**2.22 ± 2.74 / 1 (0.0-4.0)**	**2.84 ± 2.90 / 2.5 (0.0-5.0)**	**0.031**

SD, Standart deviation; P25 and P75, 25^{th} and 75^{th} percentiles; PACU, Postoperative Anesthesia Care Unit; VAS, Visual Analogue Scale (of pain).

Table 5. Predictors of core hypothermia by multiple logistic regression

Variable	**Odds ratio (95% CI)**	**p-value**	**Odds ratio (95%CI)**	**p-value**
Age≥ 65	1.71 (1.07-2.75)	0.026		
Body Mass Index (Kg/m2)	0.94 (0.89-0.98)	0.005	**0.93 (0.89-0.98)**	**0.006**
High risk surgery	1.68 (1.02-2.76)	0.041		
RCRI				
≤2	1		1	
>2	3.33 (1.15-9.60)	0.026	**3.40 (1.13-10.2)**	**0.029**
General anesthesia	2.16 (1.14-4.08)	0.018		
Warming methods	1.84 (1.15-2.96)	0.011		
Intravenous crystalloids (L.)	1.58 (1.24- 2.02)	<0.001		
Duration of anesthesia (hours)	1.50 (1.25-1.79)	<0.001	**1.52 (1.27-1.83)**	**<0.001**
Duration of surgery (hours)	1.52 (1.24-1.87)	<0.001		
VAS>3	1.86 (1.16- 3.00)	0.010	**1.74 (1.05-2.87)**	**0.031**

RCRI, Revised Cardiac Risk Index; VAS, Visual Analogue Scale (of pain).

Table 6: Vital signs in normo and hypothermic patients

Variable	Total	Normothermic	Hipothermic	p-value
SBP (mmHg)	129 ± 25	131 ± 24	127 ± 27	*0.161*
DBP (mmHg)	69 ± 14	70 ± 13	69 ± 15	*0.512*
HR (bpm)	74 ±16	75 ± 16	74 ±16	*0.630*
O_2Sat (%)	96 ± 3,4	96 ± 3	97 ± 4	*0.162*
VAS>3	**110**	**64 (28)**	**46 (42)**	***0.010***

SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; O_2Sat, oxygen saturation; VAS, Visual Analogue Scale (of pain).

European Journal of Anaesthesiology

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We would like to thank Dr John A. Smith for his assistance with the study.

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This work was supported by the Department of Anaesthesiology, London Hospital, London, UK.

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