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Blood Glucose Variability

A New Paradigm in Critical Care?

BLOOD glucose has only recently emerged as an important variable in critical care. In the past, this biologic marker has been largely ignored or considered as adaptive to the stress conditions observed in critically ill patients. In this issue of ANESTHESIOLOGY, Egi *et al.*[1] report observations from a large database that included 7,049 critically ill patients in whom blood glucose was frequently monitored. They observed that variability of blood glucose concentration was an independent predictor of intensive care unit (ICU) and hospital mortality.

It is now obvious that blood glucose plays a key role in both the short- and long-term consequences of neurologic injury.[2,3] In the heart, high blood glucose level abolishes ischemic preconditioning,[4] amplifies reperfusion injuries,[5] and provokes coronary endothelial dysfunction[6,7] and thus further increases the incidence of myocardial ischemic events. Numerous clinical studies have identified diabetes mellitus as an independent risk factor for perioperative morbidity and mortality,[8] and there is compelling evidence that perioperative glycemic control improves early clinical outcome of diabetic patients.[9] In a randomized study in critically ill patients, Van der Berghe *et al.*[10] reported that intensive insulin therapy is associated with a lower mortality. In patients undergoing coronary artery bypass surgery, we have recently demonstrated that a poor intraoperative glucose control despite intensive insulin therapy is associated with a worsened hospital outcome in diabetic patients.[11] As emphasized recently by Malhotra,[12] the days of ignoring blood glucose levels or tolerating marked hyperglycemia in the ICU are over.

In the report by Egi *et al.*,[1] blood glucose was closely monitored; on average, glucose was measured every 4 h. The mean measures were 24 per patient, and the variability of blood glucose predicted ICU and hospital mortality. In multivariate analyses, the odds ratio associated with blood glucose variability (1.28 per 1 mM of SD) and that associated with mean blood glucose (1.21 per 1 mM) were comparable in predicting ICU mortality. The results were comparable when considering hospital mortality. These results should be considered with caution because this was a retrospective study and we cannot rule out the possibility of hidden bias. Although these results are impressive and the methodology used is appropriate, including a very large number of critically ill patients, it should be noted that these associations were observed; however, this does, in itself, not prove causality. Therefore, the study from Egi *et al.*[1] should be considered as the first important step toward a new paradigm concerning the prognostic value of blood glucose concentrations: Not only the level of blood glucose but also its variability might be of paramount importance. This study constitutes a unique opportunity to orient future research, both experimental and clinical, to test this new hypothesis.

If blood glucose variability is as important as blood glucose level, some recent findings should be reconsidered. For example, using intensive insulin therapy in the ICU, the first study by Van der Berghe *et al.*[10] showed a reduction in mortality, whereas a second large trial did not.[13] Many factors might explain this discrepancy.[12] However, it should be pointed out that neither of these clinical trials assessed blood glucose variability, which might have played a crucial role. Two large ongoing randomized trials on intensive insulin therapy in the ICU might also consider blood glucose variability as an important factor.*†

Blood glucose variability has been simply assessed by the SD (or the coefficient of variation) in the study by Egi *et al.*[1] However, this variable is in fact a very complex factor that could encompass several pathophysiologic processes: variation of blood glucose around abnormal high values, variation of blood glucose between abnormal high (hyperglycemia) and low (hypoglycemia) values. Future research should be also directed to assess the more appropriate definition of blood glucose variability and to delineate the possible pathophysiologic mechanisms involved. The initial results of blood glucose variability as insulin treatment is initiated should probably be discarded. Also, this may depend on the therapeutic effort to maintain blood glucose using intensive insulin therapy. The mode of administration of insulin may affect blood glucose variability; continuous intravenous administration is better than continuous and bolus subcutaneous administration, which is better than intravenous bolus administration. Insulin itself may also induce biologic effects aside from gly-

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* National Institutes of Health: Glucontrol study: Comparing the effects of two glucose control regimens by insulin in intensive care unit patients. Available at: http://clinicaltrials.gov/show/NCT00107601. Accessed February 20, 2006.

† Current Controlled Trials: A multi-centre, open label, randomized controlled trial of two target ranges for glycaemic control in intensive care unit (ICU) patients. Available at: http://controlled-trials.com/isrctn/trial/ISRCTN04968275/0/04969275.hlml. Accessed February 20, 2006.

cemic variation; these include a decrease in level of free fatty acids, scavenging of free radicals, and even nonmetabolic biologic actions.[14–17] Here, it should be emphasized that the results observed by Egi *et al.*[12] may not apply to critically ill patients receiving intensive insulin therapy.

In the study by Egi *et al.*[1] and in a subgroup analysis, the results were not markedly modified based on whether the patients were diabetic. Also, the sample size for diabetic patients was too small to test their blood glucose level and blood glucose variability. This is important because there is evidence that the deleterious effects associated with high blood glucose in critically ill patients are not the same in diabetic and nondiabetic patients.[18] Moreover, diabetes should not be considered as a single disease because there are marked differences in diabetes types I and II. Blood glucose variability is usually less pronounced in type II diabetic patients in whom endogenous insulin secretion exists. We therefore suggest that the hypothesis for a critical role of blood glucose variability should be tested separately in nondiabetic patients and diabetic critically ill patients. Even diabetic patients should be divided by type and will require a very large multicenter study.

In conclusion, blood glucose variability and not only blood glucose level should probably be taken into account in future research on perioperative glucose monitoring and outcome. This is not really surprising because blood glucose variability has long been considered as important for the long-term care of diabetic patients.

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One Size Does Not Fit All

Genetic Variability of μ-Opioid Receptor and Postoperative Morphine Consumption

INTERINDIVIDUAL variability in pain perception and sensitivity to analgesic therapy with a large unpredictability in efficacy, side effects, and tolerance profiles to opioids is well described. Numerous candidate genes have been considered as suitable targets for the study of the genetic basis of pain.[1] The μ-opioid receptor (μOR), encoded by genetic locus *OPRM1*, has been the focus of several genetic studies because this receptor is the primary site of action for many endogenous opioid peptides, including β-endorphin and enkephalin, and the major target for opioid analgesics. Several single nucleotide polymorphisms have been identified within the μOR gene, the A118G polymorphism being the most common one.

In this issue of ANESTHESIOLOGY, Chou *et al.*[2] from Taiwan provide a brief clinical report on the effect of the A118G polymorphism of the human μOR on the intravenous consumption of morphine for acute postoperative pain. The major interest for this particular single nucleotide polymorphism is due to its pharmacologic[3] and physiologic consequences.[4–7] *In vitro*, Bond *et al.*[3] determined that the presence of at least one G118 allele increases the binding affinity and potency of β-endorphin. Therefore, individuals carrying the variant receptor gene could show differences in some of the functions mediated by β-endorphin action at the altered μOR, such as higher thresholds to pain. Consistent with this laboratory finding, one *in vivo* study in a human experimental pain model demonstrated that volunteers carrying a G118 allele exhibited indeed higher pressure pain thresholds compared with A118 homozygotes.[8] Suggested explanations were either that binding affinity is greater for β-endorphin in the presence of the G118 variant or that the A118G polymorphism is in linkage disequilibrium with another functional variant that affects pain tolerance. It is noteworthy that the *in vitro* findings of Bond *et al.* have not been confirmed by others since then; two studies actually refuted any alteration in binding affinities or potency with endorphins or any opioids in the presence of the variant μOR.[9,10] Hence, all the *in vitro* findings taken together suggest that the A118G polymorphism is more likely to have an effect on μOR function rather than binding affinity, and may affect potency and/or efficacy *via* alterations in expression, transduction systems, or receptor trafficking. To further complicate matters, a clinical study assessing the impact of the A118G polymorphism on the use of oral morphine for treatment of chronic pain in cancer patients has determined just the opposite, with higher requirements of oral morphine to achieve pain control in patients homozygous for the variant G118 allele; however, only four patients were G118 homozygous in this report.[11] Several other small series focusing on the toxicity profile of the active morphine metabolite morphine-6-glucuronide according to μOR genotype demonstrated in carriers of the G variant either a reduced clinical response,[12] a reduced analgesic effect of oral morphine without protection from respiratory depression,[13] or an increased protection from morphine-6-glucuronide–related toxicity.[14] All these conflicting and somewhat confusing findings can only leave the reader or even the most dedicated clinical researcher aspiring to elucidate the genetics of pain extremely perplexed and dubious.

So, what new evidence does the study of Chou *et al.* provide? This straightforward prospective observational study on the clinical effects of the A118G polymorphism on morphine analgesia was designed to determine the intravenous morphine consumption of women during the first 48 h after total abdominal hysterectomy. Eighty women were included into the study and were provided with an intravenous patient-controlled analgesia pump programmed to deliver relatively small doses of morphine (1 mg with a lockout time of 5 min, with a maximum dose of 15 mg over 4 h), with no additional analgesic drugs. No woman requested any rescue medication. Genotyping for the A118G polymorphism revealed a relatively high prevalence of both heterozygotes (24%) and homozygotes (23%) for the G allele, as would be predicted in an Asian population.[15] Among Caucasians, the frequency of this variant has been shown to be slightly lower and varies between 10% and 30%.[16,17] The main finding in this study, as pointed out by Chou *et al.*, is that the total dose of morphine delivered *via* patient-con-

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trolled analgesia was statistically higher in women G118 homozygotes (33 ± 10 mg) as compared with women A118 homozygotes (27 ± 9 mg; $P = 0.024$), with no repercussions on morphine-related side effects in the first 24 h postoperatively. There was no difference in morphine consumption during the second 24 h and no overall difference according to genotype during the entire 48-h study period. A recent report, and probably the first publication in the acute postoperative period, on the influence of genetic and nongenetic factors on morphine requirements and adverse effects during the first 24 h after colorectal surgery did not find an association between morphine doses and the A118G polymorphism.[18] Although there was a slight trend toward higher consumption of morphine among carriers of the G118 variant, this did not achieve statistical significance because of the small proportion of patients carrying the G118 allele within the studied population.

So what conclusions can be drawn from this report? Probably not much. Chou *et al.* stated that the human μOR A118G polymorphism affects intravenous patient-controlled analgesia morphine consumption after total hysterectomy. Can one really conclude that a difference in morphine consumption of less than 20% is of any clinical relevance, specifically when this is only true during the first 24 h? In addition, it did not bare any consequences on the occurrence of side effects, and the potential for chronic pain was not assessed. One could even argue that with a trend toward less vomiting among G118 homozygous women, this could be one explanation as to why these women were willing to request and therefore received more morphine boluses, resulting in this "higher" consumption of morphine; this report is, however, underpowered to draw any conclusions on the incidence or consequences of postoperative nausea and vomiting in this clinical setting.

Such a statement actually raises the fundamental question of what is "the relevant clinical difference" we are interested in, *i.e.*, what tangible outcome should we measure in any of our pain-related studies? Of course, no one claims that a difference in morphine dose (*i.e.*, total dose in milligrams per 24 h) *per se* is the ultimate parameter; however, this has been used in the past in so many "opioid-sparing" studies looking at the effect of various analgesic adjuncts on intravenous morphine doses for postoperative analgesia and opioid-related adverse outcomes.[19,20] The question is where should we go from here, so that a difference in 6 mg (18%) as found by Chou *et al.* does not result in the inevitable "and so what?" uttered at best by the more pragmatic among us or "is it true?" by the more sceptical?

If morphine doses, pain scores, and adverse outcome scores are not the panacea to define adequate analgesia and constitute only poor surrogate measures of optimal perioperative care, should we then not focus on identifying more appropriate outcomes? Most postoperative analgesia studies do not report on patients' mood, anxiety, and "well-being," which are important contributors to patients' perception of pain, and too few studies have attempted to define strategies to prevent the development of chronic pain after surgery in well-designed long-term outcome studies.[21,22] More qualitative descriptors are necessary to better define the complexity of pain. Therefore, there is no doubt that further studies are necessary to truly define any genetic effect of the μOR genotype on postoperative opioid requirements, patient well-being, and the more intriguing potential for the prediction of which surgical populations are likely to develop chronic pain, in order to implement analgesic strategies to prevent such undesirable long-term outcomes. The need for well-designed trials to study novel genes related to severe postoperative pain and the development of chronic pain has indeed already been strongly conveyed.[23]

In the meantime, the authors of this brief clinical study should be credited for producing one of the first "bench to bedside" reports to examine the association between the μOR A118G polymorphism and postoperative morphine analgesia. It is unfortunate, however, that within the setting of this report and bearing in mind some limitations in study design, the clinical effects of this polymorphism seem to be so minimal and of poor significance. One can only hope that the quest for any information on μOR genotype that may enable us to predict the response to μOR manipulation and allow opioid analgesic regimens to be tailored to individuals' genetic makeup is unremitting. With this challenging mission in mind and with continuous efforts to study the genetics of pain and analgesia, we might soon unravel the missing link and discover the underlying pharmacologic and physiologic mechanisms by which genetic factors do modulate pain perception, so that our laudable expectations of better pain management in the postoperative period as well as the prevention of chronic pain after surgery in susceptible individuals can be met in the near future.

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Are Your Hospital Operating Rooms "Efficient"?

A Scoring System with Eight Performance Indicators

LAST month, an anesthesiologist at a nearby community hospital phoned me to ask, "We are in discussion with the CEO about bailing us out of our financial woes. How can I figure out if our operating rooms (ORs) are efficient?" This question is increasingly common as hospitals and anesthesia groups negotiate contracts/stipends, hospitals build large expansions and want to open more ORs at 07:00 even though there are gaping holes in the current schedule, and hospitals aim to minimize complaints from the surgeon customer.

The question "Are my ORs efficient?" could be addressed *via* several methods. For example, statistical process control could be used to prospectively monitor a dashboard of items, such as the fraction of first cases of the day that start on time.[1] In this month's ANESTHESIOLOGY, Seim *et al.*[2] studied nonoperative times between cases performed back-to-back by the same surgeon. The OR of the Future used by the investigators offers a nice experimental setting to show that nonoperative times improved with parallel processing of OR tasks (*e.g.*, induction of anesthesia at the same time as the OR is getting cleaned). This required additional OR staff and an induction area.

Alternatively, "Are my ORs efficient?" could be answered with a more qualitative approach by administering a written survey to OR personnel. An example of such a survey is in the appendix. However, surveys of this type have not been validated scientifically.

I recommend that determining a hospital OR suite's efficiency should involve gathering data already available in OR information systems for analyses, without the need for an on-site consultant to collect data (until later if needed). Fortunately, the published literature to help us pinpoint which analyses can and should be done is growing. In the past decade, more than one hundred OR management articles have been published. What have we learned from these packets of information? What endpoints truly are important?

A simple scoring system to asses how well an OR suite is functioning from the hospital's perspective is summarized in table 1. The required data are readily available in any OR

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Table 1. A Scoring System for OR Efficiency

Metric	Points		
	0	1	2
Excess staffing costs	Greater than 10%	5–10%	Less than 5%
Start-time tardiness (mean tardiness of start times for elective cases per OR per day)	Greater than 60 min	45–60 min	Less than 45 min
Case cancellation rate	Greater than 10%	5–10%	Less than 5%
PACU admission delays (% of workdays with at least one delay in PACU admission)	Greater than 20%	10–20%	Less than 10%
Contribution margin (mean) per OR hour	Less than $1,000/h	$1,000–2,000/h	More than $2,000/h
Turnover times (mean setup and cleanup turnover times for all cases)	Greater than 40 min	25–40 min	Less than 25 min
Prediction bias (bias in case duration estimates per 8 h of OR time)	Greater than 15 min	5–15 min	Less than 5 min
Prolonged turnovers (% of turnovers that are more than 60 min)	Greater than 25%	10–25%	Less than 10%

OR = operating room; PACU = postanesthesia care unit.

information system. The eight objective metrics listed were chosen subjectively based on my synthesis of the relevant literature. Surgeon satisfaction is also critical, but no valid and reliable instrument to measure this has been developed.

This standardized method could be used by OR managers for evaluating baseline performance and identifying areas needing improvement. I would expect poorly managed OR suites to score 0–5 points (on the 0–16 scale), whereas high scores of 13–16 are achievable, especially with state-of-the-art management systems in place. Whether statistical process control as used by Seim *et al.*[2] can be used to assess changes in each of the metrics deserves further study.

Certainly, safety and patient outcome cannot be compromised when aiming for a more efficient OR suite.

Below I explain each of the metrics in the scoring system. I acknowledge that some metrics are related to one another, and some (*e.g.*, excess staffing costs) are more important than others even though the point system weights the metrics equally.

Excess Staffing Costs due to OR Allocation Not Being Based on Maximizing OR Efficiency

Nothing is more important in OR management than to first allocate the right amount of OR time to each service on each day of the week. To illustrate this, imagine that two cases each lasting 2 h are scheduled into OR No. 1 with OR nurses and an anesthesiologist scheduled to work an 8 h day. The matching of workload to staffing has been so poor that little can be done the day of surgery to increase the efficiency of use of the nurses and anesthesiologists. Neither awakening patients more quickly nor reducing the turnover time, for example, will compensate for management's poor initial choice of staffing for OR No. 1 and/or how the cases were scheduled into OR No. 1.

Optimal allocation of OR time needs to be based on historical use by a particular service (*i.e.*, unit of OR allocation such as surgeon, group, department, or specialty) and then using computer software to minimize the amount of underutilized time and the more expensive overutilized time.[3] The excess staffing cost[4] in the above example would be 50%. On the other hand, if 9 h of cases are performed in an OR with staff scheduled to work 8 h, the excess staffing cost is 25% (1 h/8 h = 12.5% multiplied by the additional cost of staying late, which we often assume to be approximately 2; part of that is overtime cost and part is recruitment and retention costs related to unhappy staff because they have to stay late).

Operating room suites can reasonably aim to achieve a staffing cost that is within 10% of optimal (*i.e.*, workload is perfectly matched to staffing). Importantly, for elective cases, increasing the duration of time patients have to wait to have surgery has an important effect on improving OR use because cases can be placed better. From computer simulation studies, this seems to be true in particular if average waiting time is greater than 2 weeks.

Start-time Tardiness (Mean Tardiness of Start Times for Elective Cases per OR per Day)

Reducing the time patients have to wait for their surgery after they arrive at the hospital (especially if the preceding case runs late) is another important goal for the OR manager. If a case is supposed to start at 10:00 AM (patient enters OR) but the case starts at 10:30 AM instead, then there is 30 min of tardiness. In computing this metric, no credit is given if the 10:00 AM case starts early (*e.g.*, at 9:45 AM).

The tardiness of start of scheduled cases should total less than 45 min per 8-h OR day in well-functioning OR suites. To achieve this, the OR manager can (1) properly determine when patients should be told to arrive, so as not to be too early or late; (2) schedule appropriate delays between successive

cases; (3) move cases among ORs when a preceding surgeon's case in the same OR is running late; and (4) sequence each surgeon's list of cases in the same OR on the same day, with the most predictable case first and the least predictable (often the longest) case last.[5] Facilities with long work days will have greater tardiness because the longer the day is, the more uncertainty there is about case start times.

Case Cancellation Rate on Day of Surgery

Cancellation rates vary among facilities, depending partly on the types of patients receiving care, ranging from 4.6% for outpatients[6] to 13%.[7] Many cancellations are due to nonmedical problems such as a full intensive care unit, surgeon unavailability, or bad weather (less common in Palo Alto, California). OR cancellation rates can be monitored statistically,[8] and well-functioning OR suites should have cancellation rates of less than 5%.

Postanesthesia Care Unit Admission Delays (% of Workdays with at Least One Delay of 10 min or Greater in Postanesthesia Care Unit Admission because Postanesthesia Care Unit Is Full)

It is important to adjust postanesthesia care unit nurse staffing around the times of OR admissions. Algorithms exist that use the number of available nursing hours to find the staffing solution with the fewest number of understaffed days.[9,10]

Contribution Margin (Mean) per OR Hour

An OR suite that puts up with excessive surgical times can schedule itself efficiently but still lose its financial shirt if many surgeons are slow, use too many instruments or expensive implants, and so forth. These are all measured by the contribution margin per OR hr. The contribution margin per hour of OR time is the hospital revenue generated by a surgical case, less all the hospitalization variable labor and supply costs. Variable costs, such as implants, vary directly with the volume of cases performed.

Theoretically, any case with a contribution margin greater than 0 that can be done safely is financially worth doing to a facility. This is because fee-for-service hospitals have a positive contribution margin for almost all elective cases mostly due to a large percentage of OR costs being fixed. For US hospitals not on a fixed annual budget, contribution margin per OR hour averages $1,000–2,000 per OR hour.[11–13] Contribution margin is, of course, insurance mix dependent. Therefore, hospitals with poor contracts may score poorly here despite the OR being highly efficient in other ways. For hospitals with a fixed budget, maximizing contribution margin per OR hour is equal to minimizing variable costs.

Turnover Times

Turnover time is the time from when one patient exits an OR until the next patient enters the same OR.[14] Turnover times include cleanup times and setup times, but not delays between cases. Based on data collected at 31 US hospitals, turnover times at the best-performing OR suites average less than 25 min.[15] Cost reduction from reducing turnover times (because OR workload is less) can only be achieved if OR allocations and staffing are reduced.[16] Despite this, turnover time receives lots of attention from OR managers because it is a key satisfier for surgeons.

Times between cases that are longer than a defined interval (*e.g.*, 1 h) should be considered delays, not turnovers. For example, a case scheduled for 3 h finishes after 30 min because the patient has widespread metastases. The surgeon for the to-follow case is not available for 2 h. The delay is 2 h. That delay should not contribute to calculations of turnover times.[17] Prolonged turnover times peak in the middle of the workday because most turnovers occur then.

Prediction Bias (Bias in Case Duration Estimates per 8 h of OR Time)

Prediction error equals the actual duration of the new case minus the estimated duration of the new case. Bias indicates whether the estimate is consistently too high or consistently too low, and precision reflects the magnitudes of the errors of the estimates. Efficient OR suites should aim to have bias in case duration estimates per 8 h of OR time that is less than 15 min.[18] A reason for bias can be surgeons' consistently shortening their case duration estimates because they have too little OR time allocated and need to "fit" their list of cases into the OR time they do have.

Remember that lack of historic case duration data for scheduled procedures is an important cause of inaccuracy in predicting case durations. In general, half of the cases scheduled in your OR suite tomorrow will have less than 5 previous cases of the same procedure type and same surgeon during the preceding year.[19] In fact, 37% of cases at a tertiary surgical suite did not have any cases at all in the previous year of the same procedure type and surgeon. This may be counterintuitive to many OR staff. However, the existence of thousands of combinations of scheduled surgeon and procedure is consistent with reports that many hospitals have 5,000–6,000 preference cards.[20] Each preference card defines a surgeon and a procedure (or combination of procedures).

One way to increase the amount of historical data available to make case duration predictions is to lump together similar current procedural terminology codes into buckets. Unfortunately, this is impractical because, for example, procedures

with current procedural terminology codes that differ only in the final (fifth) digit have different case times. For example, a vitrectomy (67108) may take more than an hour longer than a scleral buckle (67107).

Conclusion

Most US hospitals perform all cases scheduled by their surgeons, provided a case can be done safely. This reflects the desire to retain and grow surgeons' practices, to enhance market share and reputation, and to fulfill community-service missions. Getting the right case in the right room at the right time is the goal for every OR director. For anesthesiologists, efforts to increase anesthesia group productivity are the same as increasing the efficiency of use of OR time.

Often, though, defining how well the OR suite runs depends on who you ask. The hospital administrator may want the most "throughput" with the least cost, whereas the surgeon wants first case of the day block time, rapid turnover, low cancellation rate, and on-time starts. Nurse managers may focus more on flexibility to move cases around, disposable supply costs/case, the percentage of cases in compliance with flash sterilization policy, and having adequate reserve capacity for add-on cases or emergency cases. Risk management, on the other hand, will want to know the percentage of patients without injury (*e.g.*, wrong-sided surgery).

With proper management weeks to months ahead of time, the groundwork for an efficient (well-functioning) OR suite should be in place. This means that superhuman effort, for example, to rush around on the day of surgery trying to reduce turnover times, may be dangerous and stressful with little financial justification. On the day of surgery, the best way to proceed is by simply taking care of each patient in a relaxed, cheerful, and supportive way, having done most of the thoughtful planning ahead of time.

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Appendix: OR Personnel Survey to Assess How Well an OR Suite Is Functioning*

Please rate your level of agreement with the following statements regarding the OR suite (1 = strongly agree, 3 = neutral, 5 = strongly disagree).

1. Patients wait a minimum period of time before start of surgery	1	2	3	4	5
2. Surgeries start on time	1	2	3	4	5
3. We provide timely communications to the patient's family in the waiting area	1	2	3	4	5
4. We provide a comfortable and pleasant waiting area	1	2	3	4	5
5. We cancel few cases on the day of surgery	1	2	3	4	5
6. We practice "truth in scheduling"	1	2	3	4	5
7. We have adequate nursing support	1	2	3	4	5
8. We have adequate technician support	1	2	3	4	5
9. We have the ability to add nonelective procedures	1	2	3	4	5
10. We have short turnaround time between cases	1	2	3	4	5
11. We have reliable, high-quality equipment	1	2	3	4	5
12. Surgeons are on time	1	2	3	4	5
13. Anesthesiologists are on time	1	2	3	4	5
14. We get the required instruments properly cleaned and on time	1	2	3	4	5
15. We have reliable communication mechanisms across the OR	1	2	3	4	5
16. Other _____	1	2	3	4	5

OR = operating room.

* With permission: Sridhar B. Seshadri, M.B.A., Vice-President, Planning & Process Excellence, Stanford Hospital & Clinics, Stanford, California.

Anesthesiology 2006; 105:241–3

Gloved and Masked—Will Gowns Be Next?

The Role of Asepsis during Neuraxial Instrumentation

SINCE the discovery of "spinal anesthesia" in 1885 by J. Leonard Corning and its subsequent application in humans by Augustus Bier in 1898, close scrutiny has been paid to possible complications related to this technique. Although neurologic complications after spinal anesthesia, including aseptic meningitis, were described as early as 1936, it was not until the Woolley and Roe cases in 1947 that these complications were highly publicized. In these cases, two relatively young healthy males became paraplegic after spinal anesthesia secondary to contamination of the syringes and spinal needles by an acidic descaler.[1] Ever since, clinicians continue to improve and modify this technique to increase safety and minimize complications. In this issue of ANESTHESIOLOGY, Baer[2] presents a review of cases of post–dural puncture meningitis (PDPM) purportedly related to a dural puncture. In another report in this issue of the journal, Ruppen *et al.*[3] present a meta-analysis of well over one million parturients describing the incidence of serious neurologic injuries, including infection, after epidural analgesia and anesthesia.

A statement on regional anesthesia approved by the House of Delegates of the American Society of Anesthesiologists* states that regional techniques are best performed by an anesthesiologist who possesses competence and skills necessary for safe and effective performance. Although the statement mentions that recognition of complications and provision of appropriate postprocedure care is the duty of the physician, there is no reference to sterile technique. More importantly, a physician booklet drafted by the American Society of Anesthesiologists Task Force on Infection Control† recommends the use of maximal sterile barrier precautions during central venous catheter infection but does not address neuraxial techniques. Baer[2] correctly points out that unlike regional techniques, guidelines for the prevention of intravascular catheter–related infections were developed by practitioners who insert catheters, including intensivists and anesthesiologists.[4] They emphasize the use of maximal sterile barrier precautions during central venous catheter infection and the preferred use of 2% chlorhexidine preparation for skin antisepsis. Sterile precautions including cap, mask, sterile gown, sterile gloves, and large sterile drape have been demonstrated to reduce the incidence of intravascular catheter–related bloodstream infections when compared with standard precautions, including sterile gloves and small drapes.[5]

This begs the question of whether the same precautions ought to be used for the placement of neuraxial anesthesia. Central venous catheter–related infections are more common than neuraxial-related infections, and the use of maximum sterile barriers while placing central lines was targeted by the Agency for Healthcare Research Quality as a practice that needs more widespread implementation.[6] Interestingly, although there are no data supporting the use of all components of maximal precautions when performing neuraxial techniques, aseptic practice for neuraxial techniques varies tremendously between practitioners.[7–9] Despite the abundance of data cited by Baer[2] demonstrating that aerosolized organisms often originate from the physician performing a dural puncture, some even question the use of a surgical mask while performing these techniques. Even in the presence of laminar airflow in operating rooms, bacterial counts measured on settle plates at head and waist height were higher when either hat or mask was not worn.[10] The increase in count was greater when a mask was not worn, and the absence of both hat and a mask led to an exponential increase.[10] Other basic components of aseptic technique are often breached. Although the bactericidal effect of skin disinfectants (povidone iodine and chlorhexidine) peaks at 2 min,[4] it is common to leave skin cleansing as the last step before skin infiltration, which does not leave adequate time for disinfectants to be effective. Medications are frequently drawn up without a filter needle, although microparticles are often found in local anesthetics or other sterile solutions after the syringe has been filled.[11]

Some have expressed skepticism that true sterile technique is actually practiced. Pointing to the many possible breeches leading to potential contamination, they have emphasized the need for a consensus conference to clarify the meaning of good aseptic practice for neuraxial techniques.[7,12] To this end, the American Society of Regional Anesthesia and Pain Medicine convened a con-

This Editorial View accompanies the following two articles: Baer ET: Post–dural puncture bacterial meningitis. ANESTHESIOLOGY 2006; 105:381–93; Ruppen W, Derry S, McQuay H, Moore RA: Incidence of epidural hematoma, infection, and neurologic injury in obstetric patients with epidural analgesia/anesthesia: Meta-analysis. ANESTHESIOLOGY 2006; 105:394–9.

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* Available at: http://www.asahq.org/publicationsAndServices/standards/26.pdf. Accessed April 20, 2006.

† Available at: http://www.asahq.org/publicationsAndServices/infectioncontrol.pdf. Accessed April 20, 2006.

sensus conference on infectious risks of regional anesthesia in March 2004[13]; results of this proceeding will be published later this year in *Regional Anesthesia and Pain Medicine* and stress the need for hand washing (electronic personal communication, Joseph M. Neal, M.D., Staff Anesthesiologist, Virginia Mason Medical Center, Seattle, Washington, and Editor-in-Chief, *Regional Anesthesia and Pain Medicine*, April 2006). It has been strongly supported by well-designed studies that the use of sterile gloves does not replace the need for hand hygiene.[4] Interestingly, the Agency for Healthcare Research Quality has also targeted improved hand-washing compliance as one of the top research item topics for patient safety.[6] Furthermore, although the consensus stopped short of recommending an alcohol-based chlorhexidine antiseptic solution for skin disinfection before neuraxial techniques, it did come to the conclusion that this solution has a faster and stronger bactericidal effect when compared with povidone iodine (electronic personal communication, Joseph M. Neal, M.D., April 2006). However, an alcohol-based chlorhexidine antiseptic solution is not approved by the Food and Drug Administration for spinal technique‡ because of controversial data on its neurotoxicity. Although the data on facemasks is not as strong, there is evidence that upper mouth commensals have been implicated in cases of PDPM.[2] Because it is close to impossible to predict whether a practitioner performing a neuraxial technique will need to talk with the patient or assistant, or cough or sneeze, it would also seem prudent to wear a facemask when performing this procedure. Although Baer[2] states that all aspects of sterile technique are part of the "standard-of-care defense," there is no data that support the use of sterile gowns during the performance of neuraxial techniques.

Potential underreporting of cases of PDPM in the United States is another important teaching of Baer's article.[2] Data from other countries suggest that the incidence of PDPM is as high as 1.3 per 10,000 performed spinals (approximate range of 1:50,000 to 1:10,000); Baer's statistics suggest that the US rate is higher. The 1:10,000 figure is similar to the average risk of deadly accidents on roads or fatal undesirable healthcare outcomes.[14] If the US risk of PDPM is greater than 1:10,000, the risk of this procedure may be greater than patients' or physicians' perceptions of standard or acceptable risk. Besides recognizing and accepting this complication, anesthesiologists should be aware of the changes needed to achieve safety in medicine.[15] There are often many barriers to promoting a shift in culture, and leadership is required to advance system changes. These include the need to limit discretion and autonomy, the need to standardize practices, the need for senior leadership arbitration, and the need for simplification.[14] The recently drafted guidelines by the American Society of Regional Anesthesia and Pain Medicine have already started to address some of these barriers.

The decreased incidence of regional anesthesia–related maternal mortality[16] and the increased availability of regional anesthesia techniques over the past two decades[17] account for the marked increase in regional anesthesia and analgesia used by parturients. Even our colleagues in obstetrics have recognized that regional anesthetic–related complications are low.[18] In a recent multicenter prospective observational study on complications of anesthesia for cesarean delivery sponsored by the National Institutes of Health and written exclusively by obstetricians,[18] there were no regional anesthesia–related mortalities and a very small proportion of high spinals. Other complications such as failed regional, spinal headache, and blood patch were more common. Of note, there were no cases of epidural abscess or hematoma, or meningitis. In this issue of ANESTHESIOLOGY, Ruppen *et al.*[3] conduct the largest analysis to date on serious neurologic complications with epidural techniques in obstetric patients. The results are not surprising in view of the results of a recent European report demonstrating that parturients have a lower incidence of major or severe complications related to neuraxial techniques when compared with the general population.[19] Although epidural infection or hematoma and persistent injuries were in the single digits per million cases, transient neurologic injuries were present in 1 in 3,900 women.[3] Auroy *et al.*[20] recently wrote in an editorial in this journal that in addition to knowing rates of complication, we must find the reasons. Unfortunately, we are unable to extract from the analysis of Ruppen *et al.* the risk factors, possible reasons for complications, or whether complications were related to the epidural technique *per se*. It is also difficult to determine whether combined spinal–epidural techniques were included in the analysis. One of the largest studies included does mention that combined spinal–extradural was not quantified and indeed was treated as epidural blockade in some cases.[19] Furthermore, some of the studies used in the metaanalysis were not looking specifically at neuraxial techniques *per se*. Only if we review all complications and their patterns thoroughly, as has been done by Baer, are we going to be able to develop preventive measures such as strict aseptic technique that could potentially decrease their incidence.

These two articles should be a reminder that although neuraxial techniques are largely safe and effective, potential complications can be severe. Ruppen *et al.*[3] provides some numbers that support previous statistics on epidural techniques and neurologic complications; Baer[2] reminds us that there are some precautions, such as the use of facemasks during neuraxial techniques, that are essential, even if ignored by some. Patient safety in-

‡ Available at: http://www.fda.gov/cder/foi/label/2005/021524lbl.pdf. Accessd April 20, 2006.

cludes errors of commission and errors of omission.[6,15] If nothing else, these two articles should increase our understanding of factors that may lead to serious complications and heighten our awareness of presenting signs and symptoms. Evidence has clearly shown that aseptic techniques are effective in reducing contamination and complications in other sterile procedures such as central venous lines. Likewise, data clearly show that lack of some sterile technique such as the use of masks creates situations (higher bacterial counts) that may be potentially harmful.[21] If we are to avoid the complications that 60 yr into the future will seem obvious, we must institute uniform sterile safety practices that have been proven, or seem by common logic to be prudent, and continue to study techniques used in other arenas to determine their utility.

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