Anesthesiology 2003; 98:1415–21

Relationships between Measurement of Pain Using Visual Analog Score and Morphine Requirements during Postoperative Intravenous Morphine Titration

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Background: **Although intravenous morphine titration is widely used to obtain rapid and complete postoperative pain relief, the relationship between measurement of pain and morphine requirements varies, and the evolution of pain during titration is poorly understood.**

Methods: **Intravenous morphine titration was administered as a bolus of 2 (body weight ≤ 60 kg) or 3 mg (body weight > 60 kg) during the immediate postoperative period in the PACU. The interval between each bolus was 5 min. The visual analog scale (VAS) score threshold required to administer morphine was 30, and pain relief was defined as a VAS score of 30 or less.**

Results: **Data from 3,045 patients were analyzed. The mean initial VAS score was 73 ± 19 (mean ± SD), and the mean morphine dose required to obtain pain relief was 0.17 ± 0.10 mg/kg, *i.e.*, a median of four boluses (range, 1–20). When patients were grouped according to several classes of initial VAS score (31–39, 40–49, 50–59, 60–69, 70–79, 80–89, 90–100), it seemed that the relationship between VAS score and morphine requirements was a sigmoid curve. A VAS score of 70 or greater predicted the need for a high (>0.15 mg/kg) morphine dose (sensitivity, 0.77; specificity, 0.54). During the pain relief process, the relationship between VAS score and time was depicted by a sigmoid curve.**

Conclusion: **A VAS score of 70 or greater should be considered indicative of severe pain. The relationship between the initial VAS score and morphine requirements is not linear, and the evolution of the VAS score during the pain relief process is described by a sigmoid curve.**

RELIEF of acute pain during the postoperative period is an important task for anesthesiologists. Intravenous administration of opioids is usually recommended for acute pain relief in the immediate postoperative period,[1] and use of small intravenous boluses of morphine in the PACU allows a rapid titration of the dose needed for adequate pain relief.[1–3] Very few studies have assessed morphine titration in the postoperative period,[4,5] and the evolution of pain during intravenous morphine titration is poorly understood. We analyzed a large database of patients receiving titrated intravenous morphine in the immediate postoperative period to study the relationship between the measurement of pain using the visual analog scale (VAS) score and the amount of morphine needed to obtain pain relief. The current study addresses several major issues: (1) Is there a threshold of VAS score that should be considered to be indicative of severe pain? Although several studies have defined minor pain and/or pain relief (VAS score ≤ 30), few previous studies have tried to define severe pain.[6,7] Moreover, these studies actually compared two measurements of pain (VAS and a simplified verbal rating scale)[6,7] that assess the same parameter: the patient's perception of pain. In the current study, we used a variable that is not directly related to the patient's self assessment, *i.e.*, the amount of morphine required to obtain pain relief. (2) What are the characteristics of the relationship between initial VAS score and subsequent morphine requirements to obtain pain relief? (3) What is the evolution of the VAS score during the pain relief process?

An outstanding feature of the clinical use of opioids is the extraordinary variation in dose requirements for pain management.[8] Therefore, we believed that only a study conducted in a large population would be able to answer to these questions and that the responses would be clinically relevant despite this individual variability.

This article is accompanied by an Editorial View. Please see: Berde CB, Brennan TJ, Raja SN: Opioids: More to learn, improvements to be made. ANESTHESIOLOGY 2003; 98:1309–12.

Materials and Methods

This study was approved by the hospital Ethical Committee (Comité de Protection des Personnes se Prêtant à la Recherche Biomédicale Pitié-Salpêtrière, Paris, France). Because data were recorded without any intervention and according to a protocol already used routinely in our PACU,[4,5] authorization was given to waive informed consent.

Nurse Training

All nurses in the PACU had been trained to assess pain using unidimensional scales and to perform morphine titration. They used the VAS (0–100, hand-held slide rule

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Received from the Department of Anesthesiology and Critical Care and the Department of Emergency Medicine and Surgery, Groupe Hospitalier Pitié-Salpêtrière, Assistance Publique-Hôpitaux de Paris, Université Pierre et Marie Curie, Paris, France. Submitted for publication May 2, 2002. Accepted for publication October 29, 2002. Support was provided solely by departmental sources.

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type)[9] and a special form for data collection. When patients had difficulties in manipulating the VAS, nurses were allowed to use a numerical rating scale (from 0 to 100),[10] because these two methods are equivalent.[11]

Regimen of Intravenous Morphine Titration

A strict protocol has been implemented in the PACU after a preliminary study had determined the optimal regimen of morphine titration.[4] This protocol defined the dose of intravenous boluses of morphine, the interval between boluses, the absence of limitation on the total dose, the VAS score threshold required to administer morphine, and the criteria to stop titration. After arrival in the PACU and immediately after the patients underwent tracheal extubation and were awake, they were questioned as to the presence of pain (at least every 15 min before the onset of morphine titration) and asked to rate pain intensity on a scale (VAS). When the VAS score was greater than 30, intravenous morphine was titrated every 5 min in 3-mg increments (2 mg in patients weighing $\leq$ 60 kg), and pain was assessed every 5 min until pain relief, defined as a VAS score of 30 or less. When the patient was asleep, no attempt was made to wake him, and the patient was considered as having pain relief and a score of 0 was assigned to the patient. When pain was too severe to obtain a VAS score (patient refusal), it was scored as 100. Clinical monitoring included respiratory rate measurements, oxygen saturation measured by pulse oximetry, sedation according to the Ramsay score,[12] arterial blood pressure, and heart rate. Morphine titration was stopped if the patient had a respiratory rate lower than 12 breaths/min, had an oxygen saturation measured by pulse oximetry lower than 95%, and/or experienced a serious adverse event related to morphine administration (allergy with cutaneous rash and/or hypotension, vomiting, severe pruritus). In case of severe ventilatory depression (respiratory rate $<$ 10 breaths/min), naloxone (intravenous bolus of 0.04 mg) was administered until the respiratory rate was greater than 12 breaths/min. During the data collection period, consecutive patients who fulfilled the following criteria were included: (1) VAS score $>$ 30; (2) understanding of the unidimensional methods. Thus, patients with minor pain (defined as a VAS score $\leq$ 30), with delirium or dementia, or who were non–French speaking were not included in the study. The criterion for exclusion was interruption of morphine titration because of the occurrence of severe morphine adverse effects. Sedation was not considered a severe morphine adverse effect, as previously reported.[4,5] Patients who received other analgesics (or regional anesthesia) as a rescue procedure because of lack of pain relief with morphine were also excluded. This decision was taken by the anesthesiologist, usually in patients requiring more than 10 boluses of morphine.

Morphine Requirement

The morphine requirement (expressed as milligrams per kilogram body weight) was the amount of morphine needed to obtain pain relief (VAS score $\leq$ 30) during intravenous morphine titration. We arbitrarily decided that severe pain requires a dose of intravenous morphine greater than 0.15 mg/kg. This dose has been used in many clinical studies,[13–15] and the dose of morphine required to reach the minimal plasmatic concentration is thought to be between 0.10 and 0.20 mg/kg.[16] Nevertheless, we also tested two other thresholds, 0.10 and 0.20 mg/kg, which bracket this dose.

Statistical Analysis

Data are expressed as mean $\pm$ SD or median and 95% confidence interval in non-Gaussian variables (time delay, duration, morphine dose). Student *t* test and repeated-measures analysis of variance were used for continuous Gaussian variables. The Mann–Whitney U test was used to compare two medians. The chi-square test was used for categorical variables. Correlation between two variables was performed using the least-squares method. Sigmoid curves were determined by fitting the data to the Hill pharmacologic model (Origin 5.0; Microcal Software, Northampton, MA) according to the following equation:

$$y = y_{min} + (y_{min} - y_{max}) \cdot (1 + (x_{50} \cdot x^{-1})^{n})^{-1}$$

in which y is the observed effect at the x value, y_{min} is the minimal effect, Y_{max} is the maximal effect, x_{50} is the x value that results in 50% of the difference between y_{max} and y_{min}, and n is the Hill coefficient. To determine the threshold VAS value associated with a high morphine requirement, we divided patients according to their initial VAS score (31–39, 40–49, 50–59, 60–69, 70–79, 80–89, 90–100, each subgroup being defined by the lowest VAS score) and calculated the sensitivity, specificity, and positive and negative predictive values associated with each VAS threshold (from 40 to 90). The receiver operating characteristic (ROC) curve was analyzed, the area under the curve was calculated, and the best threshold was defined as the VAS value that minimized the distance to the ideal point of the ROC curve (*i.e.*, sensitivity = specificity = 1). When no significant difference was observed between the distances of two thresholds, the one associated with the highest sensitivity was retained. To select at random samples of patients (n = 10) according to the number of boluses used (from two to five), we used the random function of Excel 5.0 software (Microsoft Corporation, Seattle, WA). We selected the first 10 patients with the highest random number. All comparisons were two-tailed, and a *P* value of less than 0.05 was required to rule out the null hypothesis. Statistical analysis was performed using a computer and NCSS 6.0 software (Statistical Solutions Ltd., Cork, Ireland).

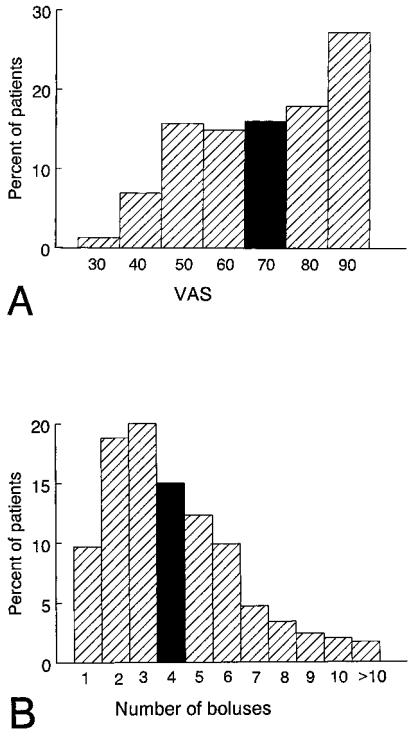

Fig. 1. (*A*) Distribution of initial visual analog scale (VAS) score, and (*B*) number of intravenous morphine boluses needed to obtain pain relief, in the whole population (n = 3,045). The VAS class corresponds to a range (*i.e.*, 40 corresponds to VAS score between 40 and 49). The *black column* indicates the median.

Results

Among 3,170 patients who fulfilled the criteria for inclusion, important data were lacking in 20 patients, and morphine titration was interrupted because of severe morphine adverse effects in 76 patients (2.4%) or administration of a rescue analgesic in 29 patients (0.9%). Therefore, data from 3,045 patients were analyzed in the study. The mean age was 50 ± 18 yr, 1,637 patients (54%) were male, 1,408 patients (46%) were female, and the mean weight was 70 ± 14 kg. The patients were admitted to the PACU after orthopedic surgery in 2,212 patients (73%), urologic surgery in 395 patients (13%), abdominal or gynecologic surgery in 181 patients (6%), vascular surgery in 98 patients (4%), and thoracic or cervicomaxillofacial surgery in 159 patients (5%). The distribution of initial VAS scores is shown in figure 1, *A*. The mean initial VAS score was 73 ± 19 (median, 70).

The mean morphine dose required to obtain pain relief was 12 ± 7 mg, or 0.17 ± 0.10 mg/kg (median, 0.15 mg/kg). Pain relief was obtained after a median of four boluses (fig. 1, *B*), with extremes ranging from one to 20 boluses.

There was a weak correlation between initial VAS score and morphine consumption (fig. 2, *A*). Nevertheless, when patients were grouped according to initial VAS score (from 31–39 to 90–100), it seemed that the relationship between VAS score and morphine requirements was a sigmoid curve (fig. 2, *B*). Indeed, the sigmoid model better fit (chi-square = 0.000008) the curve than the linear model (chi-square = 1.31). Moreover, the comparison of two consecutive medians (dose of morphine) showed two plateaus, one at the beginning (*i.e.*, VAS score of 40 *vs.* 30, not significant) and one at the end (*i.e.*, VAS score of 90 *vs.* 80, not significant) of the curve (fig. 2, *B*). The VAS_{50} that provided 50% of the maximum morphine dose was 62. The ROC curve determining the predictive value of the VAS score for a morphine requirement greater than 0.15 mg/kg was significantly different from the identity curve (area = 0.687 ± 0.022, $P < 0.05$). Two thresholds minimized the distance to the ideal point of the ROC curve (sensitivity = specificity = 1), VAS score of 70 or greater (distance = 0.519) and VAS score of 80 or greater (distance 0.514), with the difference between the two distances being not significant (fig. 3). The threshold VAS score of 70 or greater provided a sensitivity of 0.77 and a specificity of 0.54, whereas the threshold VAS score of 80 or greater provided a sensitivity of 0.59 and a specificity of 0.68. The value of 70 was thus retained because of its higher sensitivity. Table 1 summarizes the differences between patients with an initial VAS score less than 70 and those with an initial VAS score of 70 or greater. When using a different threshold for morphine dose (*i.e.*, 0.10 or 0.20 mg/kg), the areas under the ROC curve were not significantly different (0.696 ± 0.017 and 0.667 ± 0.028, respective-

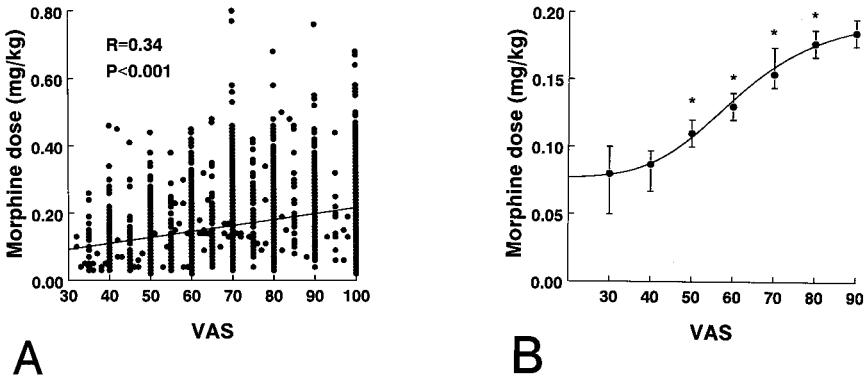

Fig. 2. Relationships between morphine dose and initial visual analog scale (VAS) score. (*A*) A significant but weak correlation between individual values is evident. (*B*) The relationship is shown between the morphine dose (median and its 95% confidence interval) in separate groups of patients according to their class of initial VAS (40 corresponds to values between 40 and 49). The dose–response curve is a sigmoid curve in which the VAS_{50} is 62. *$P < 0.05$ *versus* the previous value on the curve.

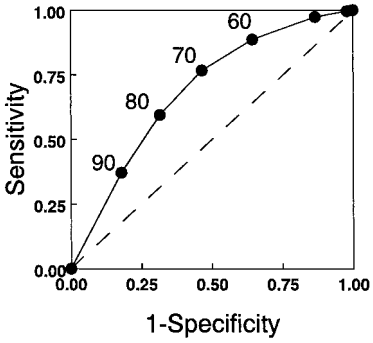

Fig. 3. Receiver operating characteristic (ROC) curve showing the relationship between sensitivity (true-positive) and 1 – specificity (true-negative) in determining the predictive value of the initial visual analog scale (VAS) score for a morphine dose greater than 0.15 mg/kg. The chosen threshold was VAS score of 70 or greater, which provided a sensitivity of 0.77 and a specificity of 0.54.

ly), and the best thresholds for the VAS score were 70 and 80, respectively (table 2).

During the pain relief process, the global relationship between VAS score and time appeared to be linear (fig. 4, *A*). Nevertheless, when patients were grouped according to the number of boluses performed (n = 1, 2, 3, 4, 5, and more than 5), each curve was a sigmoid (fig. 4, *B*). Table 3 provides the N_{50} and VAS_{max} in each of these groups. The N_{50} values (expressed as a number of boluses, 5 min elapsing between each bolus) were close to the number of boluses needed to obtain pain relief. Random samples of 10 patients from each group confirm that the individual curves were also sigmoidal (fig. 5).

Finally, we analyzed the relationship between VAS score and the need for less than one bolus of morphine to achieve pain relief. This analysis was limited to the initial period of titration, *i.e.*, the first 30 min (n = 11,380 pairs). The ROC curve determining the predictive value of the VAS score for a morphine requirement of less than one bolus was significantly different from the identity curve (area = 0.754 ± 0.018, $P < 0.05$). The threshold that minimized the distance to the ideal point of the ROC curve (sensitivity = specificity = 1) was a VAS score less than 60. A VAS score less than 60 provided a sensitivity of 0.70 (95% confidence interval, 0.68–0.72), a specificity of 0.72 (0.71–0.73), a positive predictive value of 0.43 (0.41–0.44), and a negative predictive value of 0.89 (0.88–0.90).

Discussion

In the current study, we observed that (1) a VAS score of 70 or greater should be considered to be indicative of severe pain; (2) despite important individual variability, the relationship between initial VAS score and subsequent morphine requirement is depicted by a sigmoid curve; and (3) during pain relief, the relationship between VAS score and time is also sigmoidal, indicating that the VAS score does not markedly decrease initially, but then abruptly decreases when the morphine dose approaches the dose needed to obtain pain relief.

The VAS is the most often used tool to assess pain in the perioperative period and as the outcome measure in clinical research.[17] The VAS is sensitive to pharmacologic and nonpharmacologic procedures that alter the experience of pain and highly correlates with verbal pain rating scales.[6] Although weak pain or absence of pain was prospectively defined as a VAS score of 30 or less,[7] severe pain was only arbitrarily defined as either a VAS score greater than 60[18] or greater than 75.[19] Some studies have tried to define severe pain but actually compared two measurements of pain (VAS and a simplified verbal rating scale)[6,7] that measure the same param-

Table 1. Comparison of Patients with Initial VAS Score <70 or ≥70

	<70 (n = 1,181)	≥70 (n = 1,864)	*P* Value
Age (yr)	50 ± 18	50 ± 18	NS
Male (n/%)	666/56	971/52	0.02
Female (n/%)	515/44	893/48	
Weight (kg)	70 ± 13	70 ± 14	NS
Type of surgery (n/%)			
Orthopedic	808/68	1,404/75	
Urologic	132/11	263/14	
Abdominal/gynecologic	86/7	95/5	<0.001
Cervical	90/8	24/1	
Vascular	39/3	59/3	
Other	26/2	19/1	
Initial VAS	53 ± 8	86 ± 12	–
Final VAS	17 ± 13	11 ± 14	<0.001
Dose of IV morphine (mg)	8.8 ± 5.2	13.2 ± 6.8	<0.001
Dose of IV morphine ($mg \cdot kg^{-1}$)	0.13 ± 0.08	0.19 ± 0.11	<0.001
Dose of IV morphine >0.15 $mg \cdot kg^{-1}$ (n/%)	346/29	1,139/61	<0.001
No. of boluses	3 (3-3)*	4 (4-4)*	<0.001

Data are means ± SD unless otherwise indicated. Because of rounding, percentages might not sum to 100.

* Median (CI).

IV = intravenous; NS = not significant; VAS = visual analog scale.

Table 2. Prediction of Morphine Requirement during IV Morphine Titration According to Initial VAS Score

Requirement of Morphine Predicted/VAS Threshold	Sensitivity		Specificity		Predictive Value			
					Positive		Negative	
	Value	CI	Value	CI	Value	CI	Value	CI
>0.10 mg · kg^{-1}								
≥70	0.70	0.68–0.72	0.63	0.59–0.66	0.84	0.82–0.86	0.42	0.40–0.45
≥80	0.52	0.50–0.54	0.75	0.72–0.78	0.85	0.84–0.87	0.36	0.34–0.38
>0.15 mg · kg^{-1}								
≥70	0.77	0.74–0.79	0.54	0.51–0.56	0.61	0.59–0.63	0.71	0.68–0.73
≥80	0.59	0.57–0.62	0.68	0.66–0.71	0.64	0.62–0.67	0.64	0.62–0.66
>0.20 mg · kg^{-1}								
≥70	0.80	0.77–0.82	0.47	0.45–0.49	0.41	0.38–0.43	0.83	0.81–0.85
≥80	0.63	0.60–0.66	0.63	0.61–0.65	0.43	0.41–0.46	0.79	0.77–0.81

CI = confidence interval; IV = intravenous; VAS = visual analog scale.

eter, *i.e.*, the patient's perception of pain. Bodian *et al.*[17] recently looked at the subsequent need for morphine and suggested that the VAS values should be grouped into three categories (≤30, 31–70, and >70), but this study was conducted on a long-term basis in patients receiving morphine with patient-controlled analgesia. In our study, we used the morphine dose required to obtain pain relief as an estimate of pain intensity, which is very close to the concept developed by Bodian *et al.*[17] This measurement was not completely independent from the VAS measurement, because VAS score was used to defined pain relief. In fact, we propose two ways in defining the severity of pain, the first one mainly related to the patient's perception of pain and the other one mainly based on the amount of analgesic required to obtain pain relief. This last definition may be useful in clinical practice, because it is related to the pharmacologic effort subsequently developed to obtain pain relief.

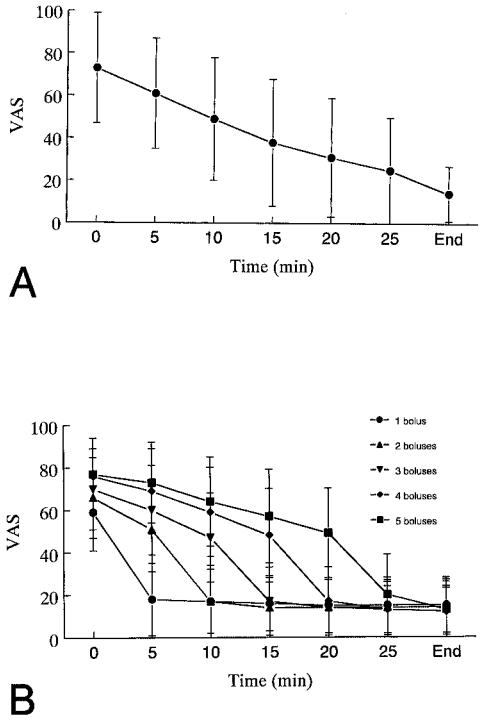

Fig. 4. Relationship between the visual analog scale (VAS) score (mean ± SD) and time (interval between two boluses was 5 min) during morphine titration and thus pain relief. (*A*) Global population. (*B*) Patients separated into groups according to the number of boluses needed to obtain pain relief.

We compared the initial VAS score and the amount of morphine needed to obtain pain relief. Using the ROC method, it seemed that two thresholds were equivalent (VAS scores of 70 and 80) in predicting the need for a high dose of morphine (>0.15 mg/kg). The threshold of 70 was retained because it has the highest sensitivity. Several arguments justify the choice of the threshold of 0.15 mg/kg. First, this dose corresponds to that administered in many randomized studies comparing morphine to other analgesics[13,14] or studying acute postoperative analgesia after anesthesia with remifentanil,[15,16] and it approximately corresponds to 10 mg morphine in an adult weighing 65 kg. Second, this dose corresponds to the median dose of morphine required to obtain pain relief in our study. When choosing another threshold of morphine dose (*i.e.*, 0.10 or 0.20 mg/kg), the VAS value retained that best predicted severe pain was also 70. Because of the very moderate differences between the two thresholds (70 *vs.* 80) in predicting severe pain, we suggest that they could be equally chosen according to the purpose of the clinician: If sensitivity is the priority,

Table 3. Parameters of the Sigmoid Curves Fitting the Relationship between VAS Score and Number of Boluses of IV Morphine in Different Patient Groups, According to Total Number of Boluses Needed to Obtain Pain Relief

No. of Boluses until Pain Relief	VAS_{max}	VAS_{min}	N_{50}
2	70	14	1.2
3	67	12	2.2
4	73	10	3.1
5	75	5	4.1

Number of boluses is equivalent to time since 5-min elapses between each bolus.

IV = intravenous; N_{50} = number of boluses required to achieve a visual analog scale (VAS score) that is the midpoint between maximum VAS (VAS_{max}) and minimum VAS (VAS_{min}).

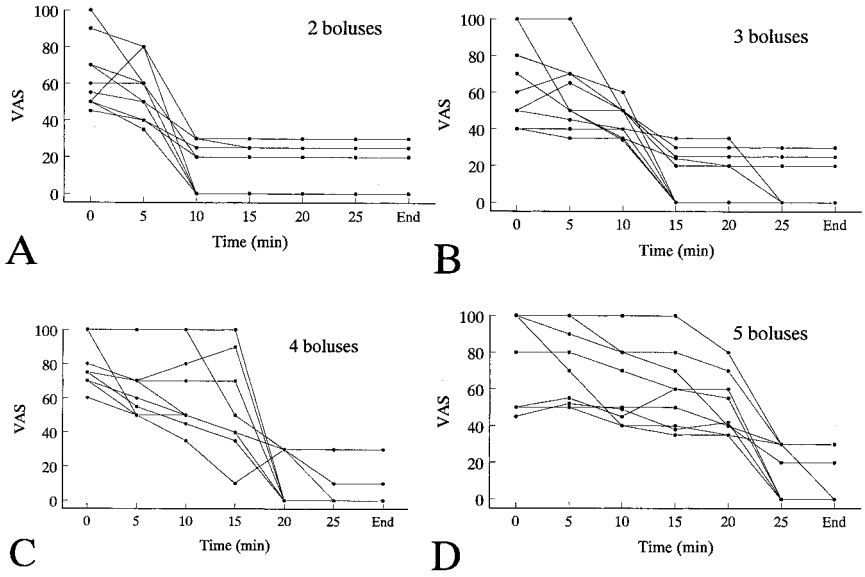

Fig. 5. Individual relationship between the visual analog scale (VAS) score (mean ± SD) and time (interval between two boluses was 5 min) during morphine titration and thus pain relief. Patients were separated into groups according to the number of boluses needed to obtain pain relief: (*A*) two boluses, (*B*) three boluses, (*C*) four boluses, (*D*) five boluses; 10 patients were randomly chosen in each group.

70 is appropriate, but if specificity is the priority, 80 is appropriate. Defining VAS values associated with severe pain may be important in clinical research to limit heterogeneity. Additive analgesic effects of codeine were observed in patients with severe but not moderate pain,[20] whereas additive analgesics effects of propacetamol could be detected only in patients with moderate pain.[21] Moreover, to identify patients with severe pain may be of special interest in clinical conditions such as emergencies in which intravenous morphine cannot be administered to every patient as in the PACU, mainly because of workload and absence of monitoring.

Two important advantages of the VAS have been advocated for its use as a measure of pain intensity. The first advantage is its precision, with a difference of 13 on the VAS representing the minimum change in pain that is clinically significant.[22,23] The second advantage is its ratio scale properties[24,25]; in contrast to other scales, equality of ratios is implied, making it appropriate to use percentage differences between VAS measurements. Myles *et al.*[26] recently supported the idea that VAS is a linear scale. However, they studied few patients (n = 52) who had moderate pain and thus recognized that they were not able to analyze the entire range of pain intensity. In our study, the relationship between VAS score and morphine requirements was depicted by a sigmoid (fig. 2) with two plateaus below 40 and above 80, respectively. These results are in accordance with those of Bodian *et al.*,[17] who suggested that VAS values should be grouped into three categories (≤30, 31–70, and >70) in patients receiving morphine with patient-controlled analgesia, and those of Bird *et al.*,[27] who observed that clinically significant changes in pain are not uniform along the entire VAS. The relationship between VAS score and morphine requirements (fig. 2) may reflect the relationship between VAS score and pain intensity. Nevertheless, there are intrinsic problems with the use of the VAS, mainly related to floor and ceiling limits imposed on data[27] that may at least partly explain the relationship observed in our study. Despite this, our current and previous studies[27,28] strongly suggest that the VAS neither represents a classic rank-ordering scale nor is composed of purely interval data, at least when considering the two extremes, moderate and very severe pain. The relationship between initial VAS score and morphine dose (fig. 2, *B*) may have important consequences for therapeutic trials. Indeed, this curve suggests that initial VAS score should be taken as an important covariate when comparing the morphine-sparing effect of an analgesic drug to increase the power and limit the consequences of heterogeneity.[29]

The time course of VAS scores during pain relief has not been appropriately studied during intravenous morphine titration, although we previously observed a linear relationship between VAS score and time.[4,5] Nevertheless, this description does not appropriately describe the phenomenon because this relationship drawn on the global population does not take into account that some patients experienced pain relief after various time intervals corresponding to a various number of morphine boluses. When we looked for patients who experienced pain relief at identical time intervals (*i.e.*, identical number of boluses), we observed that the relationship between VAS score and time was described by a sigmoid curve (fig. 4, *B*). Obviously, the linear relationship observed with all patients (fig. 4, *A*) was only the result of the addition of several sigmoid curves. This result has two implications. First, it represents an additional argument against the linear nature of the VAS. Second, because this sigmoid relationship is also true on an individual basis, it has important consequences for the conduct of morphine titration. Nurses and physicians should be aware that, during morphine titration, the VAS score does not markedly change until the morphine dose ap-

proaches (within one bolus; table 2) that dose ultimately needed to obtain pain relief, when it then abruptly decreases. Moreover, during morphine titration, a VAS score less than 60 is significantly associated with a residual need of only one bolus of morphine. We think that the knowledge of the time course of VAS scores during the pain relief process may help care providers in administrating intravenous morphine.

Some remarks must be included to assess the limitations of our study. First, we excluded some patients who experienced morphine-related severe adverse effects and those who were not able to understand the VAS. We have recently observed that our nurses had to use a simple verbal rating scale in 10% of our patients and a subjective behavioral scale in 7% of our patients.[30] Second, we excluded patients whose pain could not be relieved and who required rescue analgesics. However, we considered the possibility of bias to be unlikely because of the low number of these patients (0.9%). Third, the VAS assumes that pain is a unidimensional experience. Although intensity is a very important dimension of pain, it is clear that pain refers to a variety of sensations that cannot be categorized under a single linguistic label that varies only in intensity.[31] Nevertheless, it should be pointed out that the VAS has been widely accepted because of its ease and brevity of administration, its minimal intrusiveness, and its conceptual simplicity.[31] Fourth, the amount of morphine used to alleviate pain is not only dependent on pharmacodynamics but also on pharmacogenetics and pharmacokinetics. Thus, further studies including morphine and morphine metabolite dosage are required to better understand the relationship between morphine requirements and measurement of pain. Lastly, the results apply only to the immediate and short postoperative period of intravenous morphine titration in the PACU. We did not evaluate the relationship between VAS score and pain on the ward or during continuous administration of morphine by patient-controlled analgesia[17] or during chronic pain treatment.[32]

In conclusion, we proposed that a VAS score of 70 or greater should be considered to be indicative of severe pain. The relationship between initial VAS score and morphine requirements is not linear but described a sigmoid curve with a plateau above 80. The relationship between VAS score and time during the pain relief process is also described by a sigmoid curve, indicating that VAS score does not markedly change until the morphine dose approaches that dose ultimately needed to obtain pain relief, when it then abruptly decreases.

The authors thank all nurses of the PACU (Department of Anesthesiology, CHU Pitié-Salpêtrière, Paris, France) for their work on this study and David Baker, D.M., F.R.C.A. (Department of Anesthesiology, CHU Necker-Enfants Malades, Paris, France) for reviewing the manuscript.

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