SLIDING SCALE MORPHINE FOR THE MANAGEMENT OF SEVERE PAIN

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ABSTRACT

Due to its quick onset of action and short half-life, intravenous (IV) morphine is commonly used to treat patients with severe pain. While effective, current regimens that employ IV boluses for titration and fixed infusion rates for maintenance are not efficient, as they lack the flexibility to adjust rapidly to fluctuating pain levels. This results in either the under or over medication of patients, and many phone calls to physicians regarding new orders for pain control. This paper outlines the procedural mechanics to effectively and efficiently use IV morphine by continuous infusion for titration and sliding scale maintenance of patients with severe pain.

KEY WORDS

1. Morphine sulfate
2. Sliding scale regimen
3. Intravenous continuous infusion
4. Severe pain management
5. Titration phase
6. Maintenance phase

INTRODUCTION

Though morphine can be easily administered by either oral (PO), intramuscular (IM) or intravenous (IV) routes, parenteral morphine is the standard for severe pain control (1). Administered by IV, morphine has a 15 to 30 minute average time of onset (2), and a half life of approximately 3 hours (3), providing rapid analgesia that is easily titrated thanks to its short duration of action. In comparison, while IM and PO preparations of morphine do have the same half life as IV morphine, IM serum levels can be erratic due to local perfusion factors at the site of injection (4), and PO serum levels can be affected by the first pass effect of liver metabolism (5). Therefore, IV morphine offers the advantage of a reliable time of onset.

This paper discusses the novel use of IV morphine on a sliding scale for the management of severe pain. To this author's knowledge, no other paper has been written to date on this subject. Therefore, the purpose of this article is to outline the procedural mechanics of using morphine in this new way.

It will be assumed that the reader is knowledgeable about issues concerning the use of narcotic medications for pain management. Therefore, topics such as the definition and evaluation of severe pain, morphine regimens commonly used today, and ethical issues surrounding pain management will not be discussed here. The reader is encouraged to supplement this paper with other, amply available literature to address these issues.

CASE HISTORY

In 1997, a 40 year old male diagnosed with septic rheumatoid arthritis was admitted to the intensive care unit (ICU) of the hospital where I was employed. During his course of treatment, the sepsis invaded many areas of his body, including skeletal structures, resulting in the excision of several joints and his coccyx. Throughout much of his admission, this patient's pain was so severe that even the light pressure of laying a stethoscope on his chest produced agonizing reactions. Compounded by the complexity of his ongoing pathology, it was often difficult to keep up with his rapidly fluctuating level of discomfort. In an effort to balance his pain management needs against other medical considerations, including prolonged periods of intubation with mechanical ventilation, I synthesized a new protocol for administering IV morphine on a sliding scale where the infusion rate was matched to his systolic blood pressure measurements. This allowed the nursing staff to quickly adjust the medication's level and provide sustained pain control without adverse reactions. Ultimately, this patient succumbed to his ailments and passed away after four months of continuous admission and care in the ICU. It is noteworthy, however, that during this entire period, no other regimen provided as successful control of this patient's severe pain as did the IV morphine by sliding scale.

Shortly after seeing this patient, I retired from the hospital work force in favor of doing out-patient consultations in pain management. Though I have not used this protocol since then, over the years I have refined the original procedures. As I no longer work in the critical care environment where it would be of the most use, I present it here for others to consider.

BACKGROUND

Today, with the renewed interest and emphasis on pain control for patients with acute, chronic and terminal illnesses, it is imperative to maximize the benefits while minimizing the side effects of narcotic medications. Eliminating under and over dosing of pain medications by tightly controlling titration and maintenance dosages is one way of achieving these goals.

The concept of sliding scale medication is not new in the hospital setting, as insulin is commonly administered by this method (6). It allows for rapid adjustment in medication levels to meet patients' ever changing insulin needs. It also minimizes medication peaks and troughs that are commonly seen in non-flexible fixed dosage regimens.

The experience of pain is easily influenced by innumerable physiological, psychological and environmental factors that can provoke or palliate a patient's level of pain. Thus, like diabetics, pain patients often have fluctuations in their symptoms, and they need the ability to adjust their medications rapidly in response to these changes. For patients who can tolerate PO administration, easements and exacerbations of mild to moderate pain are commonly treated with oral regimens that allow additional dosages for break through pain and reduced dosages during periods of abatement. However, patients with severe pain are different.

Severe pain can accompany and complicate catastrophic illnesses such as delirium, shock, and cardiac arrest. Eliminating severe pain may aid in the diagnosis (7), thereby preventing the

progression, of these disease processes. Patients in severe pain should be managed aggressively in an emergency or intensive care setting until the pain and its underlying pathology are resolved. As previously discussed in the introduction, PO and IM routes of morphine administration may not have reliable times of onset, due to the first pass effect of liver metabolism (5) and erratic serum levels (4), respectively. This can make them ineffective in treating severe pain. Other routes such as transdermal, submucosal and rectal are also suboptimal, due to the inability to precisely control the timing and amount of the dose absorbed. Thus, for many severe pain patients, IV morphine is ideal.

IV morphine allows the ability to quickly titrate and rapidly adjust medication levels. Conversely, as severe pain is an emergent condition, current regimens require constant monitoring to ensure the dosage is sufficient and without adverse effects. This can make IV morphine time and labor intensive to use. However, when applied by sliding scale, it can be quickly titrated and rapidly adjusted by support staff, maximizing patient comfort while minimizing both adverse reactions and phone calls to physicians.

MANAGEMENT: VITAL SIGNS

Sliding scale IV morphine is managed by monitoring and maintaining vital signs within predetermined, acceptable ranges. The four classic vital signs – respirations, pulse, blood pressure and temperature – are the key to this method for managing severe pain, just as blood glucose levels are the key to managing sliding scale insulin. Though each patient must be assessed on their individual merits, most can be treated effectively with IV morphine as long as their vital signs remain within normal limits. However, given patient variability, it is important to remember that everything presented here can and should be tailored to meet the specific needs and limitations of the patient.

The first step before initiating IV morphine, is to select which vital signs to monitor. Under certain circumstances, not all of them need to be considered. Respirations, for example, would not have to be monitored, for IV morphine purposes, in an intubated patient controlled on a ventilation respirator. However, for this paper, all vital signs will be taken into account.

As we cannot directly see or measure any patient's pain, vital signs can be used to indirectly assess whether pain control is insufficient, adequate or excessive. Pain medication insufficiencies tend to increased mental and physiological stress, producing tachypnea, tachycardia and a hypertensive state reflected by elevations in respirations, pulse and blood pressure. In comparison, pain medication excesses often create over sedation which can decrease mental and physiological stress, yielding dyspnea, bradycardia and a hypotensive state reflected by declinations in respiration, pulse and blood pressure.

While this author knows of no documentation to link temperature with the effectiveness of pain control, febrile patients can experience generalized body aches which, by cumulative effect, may further burden the severity of pain a patient is experiencing. On the other hand, a hypothermic patient may be at risk of decreased mental status. Therefore, it is advisable to consider a patient's temperature when treating severe pain, to compensate for the additional aches associated with fevers and avoid exacerbating the mental confusion seen in those with abnormally low temperatures.

Once the clinician selects the vital signs to be monitored, the next step is to determine which lower limits, upper limits and target ranges to use. There is no one specific set of ranges that is appropriate for all clinical scenarios, as the treating physician must take into account concomitant pathology and their prior experience in treating a patient. However, given the author's general clinical knowledge, and assuming pain is the only significant factor contributing to vital sign fluctuations in a patient who usually has average vital signs (R 14, P 80, BP 120/80, T 98.6), the following ranges are suggested:

Vital Sign	Lower Limit	Target	Upper Limit
Respirations (per minute)	10	12 - 16	18
Pulse (per minute)	60	70 - 90	100
Systolic (mm Hg)	90	100 - 130	140

Diastolic (mm Hg)	60	65 - 85	90
Temperature (Fahrenheit)	97.0	98.0 - 99.0	100.0

In addition to the above, patients on IV morphine should lack any signs or symptoms of a Narcotic Adverse Reaction (NAR), such as grogginess, confusion, decreased mental status, decreased arousability, nausea, urinary retention, itching or anaphylaxis. Constipation is a common side effect of all narcotic medications and, if treatable with stimulant laxatives, is not considered to be a NAR.

TITRATION PHASE: CONTINUOUS INFUSION

As rapid injections increase the likelihood of over-medicating patients and provoking NAR's, this titration method uses IV morphine by continuous infusion pump, rather than the common practice of giving IV boluses every 10 minutes (8). The titration drip factor is 0.18 mg/kg/hr. It is derived from the bolus factor of 0.03 mg/kg (8) which, for a 70 kg patient would yield a 2.1 mg bolus of morphine every 10 minutes, or, if given at this rate continuously, 12.6 mg total by boluses over one hour. For the same patient, titrating at 0.18 mg/kg/hr also yields an hourly dose of 12.6 mg of morphine, or a 10 minute interval dose of 2.1 mg.

It is arguable that the bolus method will produce faster peak serum levels than the continuous infusion. However, as calculated above, the same amount of IV morphine will be delivered by either procedure during each 10 minute interval: immediately by bolus or gradually by drip. Therefore, though peak coverage may be delayed by at most 10 minutes, the continuous infusion offers more control over the amount of medication administered, with less likelihood of provoking NAR's.

To begin titration, first determine if the patient is currently using narcotics for pain management (see illustration #1 for titration order documentation). If the patient is not using narcotic medications, start the continuous morphine drip at 0.18 mg/kg/hr. If the patient is using a narcotic other than morphine, stop that medication and begin the IV morphine hourly rate at two-thirds the equianalgesic level of the discontinued narcotic. If the patient is already on IV morphine - drip or bolus - then begin titration by continuous infusion at the current hourly rate.

Whichever of these three starting points is used, titrate the hourly rate upwards by 0.18 mg/kg/hr every 10 minutes in an additive fashion. Therefore, if the titration starts at 0.18 mg/kg/hr for the first 10 minutes, during the second 10 minute interval of titration it will be raised to 0.36 mg/kg/hr, during the third 10 minute interval of titration it will be raised to 0.54 mg/kg/hr, and so on.

During titration, monitor the patient every 10 minutes for NAR's, vital signs, and level of pain on a scale of 0 to 10, where 0 equals no pain, until one of the following occurs:

1. The patient presents with one or more NAR's.
2. One or more vitals signs go above the upper or below the lower acceptable limits before the patient reaches adequate analgesia.
3. The patient claims to have adequate analgesia (0-3 on a scale of 0-10).

For conditions 1 or 2 above, stop the morphine titration immediately. Treat the unwanted condition until it resolves and the patient is stabilized with all vitals signs at or within acceptable upper and lower limits. Be sure to consider and rule out all non-morphine causes for the adverse effect. Once reversed, re-titrate the IV morphine drip starting at two-thirds the hourly rate at which it was stopped, titrating it upward by 0.09 mg/kg/hr every 10 minutes, and still monitoring every 10 minutes as before. If during the second attempt at titration the patient again presents with either conditions 1 or 2 above, stop the IV immediately and consider the patient to be hypersensitive or allergic to morphine. Assess and treat the new unwanted condition and begin a non-morphine protocol.

For patients presenting with adequate analgesia (0-3 on a scale of 0-10), with all vitals signs at or within acceptable upper and lower limits, and without the onset or return of NAR's, stop the titration orders, and begin sliding scale IV morphine orders as outlined below.

MAINTENANCE PHASE: SLIDING SCALE

At the onset of the maintenance phase, it is important to consider renal and hepatic function which may be altered in the elderly and those with a history of kidney or liver disease. As morphine is metabolized primarily to inactive metabolites, adverse effects from declining elimination activity are usually minimal (9), except in cases of severe organ pathology (10). However, the patient's age and hepato-renal function should be taken into account when preparing to administer the sliding scale.

Assuming normal liver and kidney function, once the patient is titrated to adequate analgesia, reduce the continuous IV infusion hourly rate to one-sixth of the loading dose given during the titration phase. The one-sixth factor is derived by using morphine's elimination half-life of 3 hours (3). After titration, the patient will eliminate approximately half of the loading dose within 3 hours. If the loading dose is maintained by continuous infusion, then every 6 hours, a complete loading dose will be eliminated. Thus, to begin the maintenance phase, set the hourly drip rate to one-sixth of the total morphine delivered in titration, so as to replenish the loading dose every 6 hours as it is eliminated.

During the maintenance phase, the goal of the sliding scale order is to keep the vitals signs within their narrower target ranges (see above), rather than the broader upper and lower limits used during titration (see illustration #2 for sliding scale order documentation). This allows the morphine to be continually adjusted before the patient experiences either pain due to insufficient medication or NAR's due to excessive infusion, and without constantly phoning the physician for new orders. Also, if the pain lessens as the underlying pathology resolves, the sliding scale automatically tapers the

patient's infusion rate downward toward cessation of the medication.

Anytime during the maintenance phase that sliding scale dosage adjustments are necessary, monitor the patient for NAR's, vitals signs and level of pain every 10 minutes. If the patient has received adequate analgesia without IV rate changes for 1 hour, then monitor them every hour for the next 24 hours, gradually increasing the interval thereafter to a maximum of every 4 hours while the dose rate continues to remain constant.

If during the maintenance phase a vital sign falls below its target range but is at or above its lower limit, and all other adverse factors that could be affecting the patient have been ruled out, then the narcotic rate is too high. The sliding scale decreases the IV morphine by 10% every 10 minutes with patient monitoring until the target range is reestablished. If the vital sign in question drops below its lower limit, then the sliding scale stops the IV morphine and proceeds as outlined below.

If during the maintenance phase a vital sign rises above its target range but is at or below its upper limit, and all other adverse factors that could be affecting the patient have been ruled out, then the narcotic rate is too low. The sliding scale increases the IV morphine by 10% every 10 minutes with patient monitoring until the target range is reestablished. If the vital sign in question rises above its upper limit, then the sliding scale stops the IV morphine and proceeds as outlined below.

It is possible that vital signs may go in different directions simultaneously, resulting in one set of vitals falling into the range requiring a decrease of IV morphine, while another set rises into the range

requiring an increase of IV morphine. In this event, the sliding scale orders include a provision which instructs the nursing staff to call the physician without changing the infusion setting. The physician should then assess the patient to determine if any concomitant pathology needs to be addressed, and which, if any, of the alterations in vital signs dictates an adjustment in the IV morphine's rate.

Any time during the maintenance phase that vital signs fall below their lower limits or rise above their upper limits, stop the IV morphine immediately and treat all non-narcotic causes for the changes. If the alterations were less than 10% above or below the upper or lower limits respectively (use $\pm$ 1% for temperature), and the patient is re-stabilized, then restart the IV morphine at the rate at which it was stopped. Otherwise, re-titrate the patient starting at two-thirds the rate when the morphine was stopped, increasing it 0.09 mg/kg/hr every 10 minutes, while monitoring every 10 minutes as before.

If the patient complains of inadequate analgesia during the maintenance phase, resume titration by increasing the current infusion rate 0.09 mg/kg/hr every 10 minutes, monitoring every 10 minutes.

Whenever re-titration is done after starting the sliding scale, once adequate analgesia recurs, reduce the new loading dose to one-sixth as outlined above, before resuming the maintenance phase.

If NAR's present during or in-between the sliding scale adjustments, stop the IV morphine immediately and treat the patient as outlined during the titration phase above. Discontinue the morphine in favor of other pain medications if this is the second time NAR's present, including any NAR's that may have occurred during the original titration.

SUMMATION

With carefully tailored, written orders, IV morphine can be titrated by continuous infusion and maintained by sliding scale to rapidly meet the evolving needs of patients with severe pain. The protocol presented here reduces the chance of either over or under-medicating patients, and stays ahead of the onset of both pain symptoms and adverse medication reactions.

ILLUSTRATION #1: INITIAL TITRATION ORDERS (NARCOTIC NAIVE PATIENT)

1. Record vital signs now and start the IV morphine infusion at 0.18 mg/kg/hr.
2. Titrate IV morphine upward 0.18 mg/kg/hr every 10 minutes, monitoring for vital signs and narcotic adverse reactions every 10 minutes.
3. Stop the IV morphine and call the doctor if any narcotic adverse reactions appear or any vital signs fall outside the following ranges:

Respirations:	10-18
Pulse:	60-100
Systolic pressure:	90-140
Diastolic pressure:	60-90
Temperature:	97.0-100.0

4. If the patient claims to have adequate analgesia (0-3 on a scale of 0-10, 0 = no pain), with their vitals signs within the ranges listed in #3 above, and without the presence of any adverse narcotic reactions, then:
    A. Reset the IV morphine rate to 1/6 of the total loading dose given.
    B. Call the doctor to confirm the new IV morphine rate setting.
    C. Stop these titration orders (#1-4).
    D. Start the IV morphine sliding scale as outlined below.

ILLUSTRATION #2: INITIAL SLIDING SCALE ORDERS (POST TITRATION)

1. Record vital signs now, then monitor the patient for vital signs and narcotic adverse reactions every 10 minutes.
2. If any adverse narcotic reactions occur, stop the IV morphine and call the doctor.
3. If the patient complains of inadequate analgesia (>3 on a scale of 0-10, 0 = no pain), then call the doctor.
4. Adjust the IV morphine according to fluctuations in vital signs as follows:

	Stop The IV And Call The Doctor	Decrease IV 10% Every 10 Minutes	Keep Current IV Rate Running	Increase IV 10% Every 10 Minutes	Stop The IV And Call The Doctor
Respirations	<10	10-11	12-16	17-18	>18
Pulse	<60	60-69	70-90	91-100	>100
Systolic	<90	90-99	100-130	131-140	>140
Diastolic	<60	60-64	65-85	86-90	>90
Temperature	<97.0	97.0-97.9	98.0-99.0	99.1-100.0	>100.0

5. If vital signs are in the “Decrease IV” and “Increase IV” ranges simultaneously, then call the doctor and do not change the IV morphine.
6. Anytime the patient requires no alterations in the IV morphine rate for more than 60 minutes, increase monitoring intervals from every 10 minutes to every 60 minutes. Revert back to 10 minute monitoring intervals whenever the IV morphine rates are altered.

REFERENCES:

1. Supernaw RB. Pharmacotherapeutic management of selected pain phenomena. In: Weiner RS, editor. Pain management, a practical guide for clinicians, 5th ed.. Boca Raton: St. Lucie Press, 1998: 137-150.

2. American Pain Society. Principles of analgesic use in the treatment of acute pain and cancer pain, 4th ed.. Glenview: American Pain Society, 1999: 17.

3. Ibid, 18.

4. Grabinski PY, Kaiko RF, Rogers AG, Houde RW. Plasma levels and analgesia following deltoid and gluteal injections of methadone and morphine. *J Clin Pharm* 1983; 23: 48-55.

5. Glare PA, Walsh TD. Clinical pharmacokinetics of morphine. *Ther Drug Monit* 1991; 13(1): 1-23.

6. Hanish LR. Standardizing regimens for sliding-scale insulin. *Am J Health Syst Pharm* 1997; 54(9): 1046-7.

7. Yealy DM, Paris PM. Pain management in the emergency department. In: Weiner RS, editor. Pain management, a practical guide for clinicians, 5th ed.. Boca Raton: St. Lucie Press, 1998: 495-504.

8. Edwards WT, Breed RJ. Treatment of postoperative pain in the post anesthesia care unit. *Anesthesiol Clin N Amer* 1990; 8: 235-265.

9. Purdue Pharma L.P., Purdue Frederick Company, sponsors. Pain management prescribing guide: classes II, III and IV opioid analgesics. Montvale: Medical Economics Company, 2001: 63.

10. Semla TP, Beizer JL, Higbee MD. Geriatric dosage handbook, 4th ed.. Hudson: Lexi-Comp, Inc., 1998: 640.