Clinical experience with continuous epidural infusion of bupivacaine at 6 ml per hour in obstetrics

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Maintenance of continuous epidural analgesia for obstetrics by slow infusion is a feasible alternative to maintenance by intermittent injection. The method described by Davies and Fettes using 0.25 per cent bupivacaine through a 6 ml/hr capillary flow device (Intraflo®), with the fast-flush cut-off, is simple and convenient. However, failure of the fast-flush valve, resulting in a high flow rate, has been reported. It is therefore imperative that, prior to connecting the pressurized system to the epidural catheter, correct function of the device be verified by observing the flow rate in the microdrip chamber. We have used this method for the past year and found the equipment reliable, but in order to achieve more satisfactory analgesia the concentration of the infusion was increased initially to 0.375 per cent, and then reduced to 0.30 per cent.

The records of the first 187 patients were reviewed retrospectively. Group I (n = 99) received an infusion of 0.25 per cent bupivacaine, Group II (n = 49) received 0.30 per cent and Group II (n = 39) received 0.375 per cent. Significantly more patients in Group I (30 per cent) required supplementary top-ups (in addition to the infusion) for the first stage of labour than in either Group II (10 per cent), or Group III (13 per cent). Top-ups for delivery were given to 55 per cent of patients in Group I, 64 per cent in Group II and 48 per cent in Group III. The incidence of motor block was significantly higher in Group III (21 per cent) than in either Group I (1 per cent) or Group II (2 per cent). For continuous epidural infusion at 6 ml/hr, 0.30 per cent bupivacaine combines optimum analgesia with minimal side-effects.

Key words

ANAESTHESIA: obstetric; ANAESTHETIC TECHNIQUE: continuous epidural, epidural infusion; ANAESTHETICS, LOCAL: bupivacaine.

Continuous lumbar epidural block is generally considered to be the best method of providing maternal analgesia[1,2] whilst simultaneously conferring positive benefits to the foetus.[3] Disadvantages have been stated to include increased personnel requirements, a higher incidence of forceps deliveries, and complications which may arise from the epidural itself.[4] An endeavour was made to improve the continuous epidural service in a community hospital undertaking 2,500 deliveries per annum, but the nurses were unwilling to administer epidural injections, and the anaesthetists reluctant to allow them to do so. Thus all such injections are administered by an anaesthetist, whose duties may not be confined to the obstetric suite, and delays in topping-up inevitably occur. The method described by Davies and Fettes[5] for continuous infusion epidural analgesia in obstetrics using 0.25 per cent bupivacaine through the 6 ml/hr Intraflo* capillary flow device (Figure 1), offered a simple solution and used equipment already available in the hospital. Since no mechanical device should be considered foolproof, specific protocols were carefully drawn up for the induction of the epidural block,

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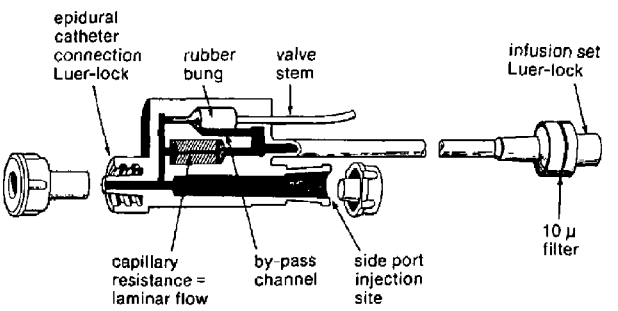

FIGURE 1 Cross-section through the Intraflo® continuous flush device.

setting up the infusion, and the management of the patient.

Initially, 0.25 per cent bupivacaine was employed in the infusion, but to achieve satisfactory analgesia even for the first stage of labour, supplementary top-ups were frequently required. Consequently the concentration was increased to 0.375 per cent, which gave excellent analgesia, but was accompanied by an undesirable increase in motor block and occasional episodes of hypotension. Reducing the concentration to 0.30 per cent appeared to combine optimal analgesia with a minimal incidence of side effects.

To examine our clinical impressions, the records of the first 187 patients were reviewed retrospectively, and the data subjected to statistical analysis.

This paper presents our clinical method and reports the results of this study.

Methods

Induction of the Epidural Block

The block was performed by the anaesthetist assigned to the obstetric suite. The procedure was explained to the patient and her written consent obtained. A minimum of 500 ml of Ringer's Lactate was administered intravenously. With the patient in the lateral position the epidural space was located at the L2-3 or L3-4 level. One-third of the initial dose of 0.25 per cent bupivacaine (usually a total of 9–12 ml) was injected through the needle. After advancing the epidural catheter 3 or 4 cm, the next one-third of the dose was injected. The catheter was taped to the back with a transparent dressing to facilitate later inspection. The patient was turned onto her other side, the blood pressure and foetal heart rate were recorded, and the remaining one-third of the dose injected. Thus a minimum of 6 to 8 ml 0.25 per cent bupivacaine had been injected through the epidural catheter. Blood pressure and foetal heart rate were monitored for the next 20 minutes, after which motor power in the legs was roughly assessed by the patient's ability to move her legs, and the level of sensory block determined using an alcohol swab to test the level at which temperature sensation was lost.[6] The infusion was then connected to the epidural catheter.

Preparation of the Infusion

Ten ml was withdrawn from a 50 ml bag of normal saline via the administration port and discarded. The appropriate amount of bupivacaine was added through the same port to make the required concentration (Table I). The spike of a Luer-Lock micro-drip infusion set (Sorenson AD 72 NV) was inserted, and the air evacuated by squeezing the inverted bag (drip set upwards) with the clamp open. A small amount of solution was allowed into the drip chamber at the same time, and the clamp closed. The bag was hung in the infusor pump and, at normal pressure, the solution was run through the infusion set. The 6" input line of the Intraflo was connected, and the Intraflo flushed by removing one of the yellow caps and pulling on the red valve stem. The valve closed when released. The pump was inflated to 300 mmHg whilst ensuring that the lower edge of the solution bag was positioned exactly along the lower edge of the cover. (This manoeuvre

TABLE I Preparation of bupivacaine/saline mixtures used for infusion at 6 ml/hr

0.25%	(15 mg/hr)	40 ml 0.9% NaCl + 40 ml 0.5%	= 80 ml 0.25%
0.30%	(18 mg/hr)	40 ml 0.9% NaCl + 60 ml 0.5%	= 100 ml 0.30%
0.375%	(22.5 mg/hr)	40 ml 0.9% NaCl + 40 ml 0.75%	= 80 ml 0.375%

is facilitated by looping an elastic band through the top of the solution bag, and passing the loop of the pump through this, thereby allowing the bag to be pulled down while inflating.) The drip chamber was observed to verify closure of the valve. The fast-flush valve was rendered inoperative by cutting off the valve stem whilst pulled in the flush mode. When released quickly the valve closed, and the cut end retracted into the plastic housing. Correct function of the Intraflo was confirmed by a micro-drip count of 6 drops/minute before connecting the pressurized system to the epidural catheter.

Management of the Patient with an Infusion Epidural

Every 30 minutes the nurse recorded maternal blood pressure, foetal heart rate, and the level of sensory analgesia. Motor power in the lower limbs was assessed, and the rate of infusion and the infusion pressure were checked. The patient was asked to turn herself onto her other side every half hour, or to lie on the least analgesic side. Patients were specifically instructed to immediately inform the nurse should they be unable to move their legs. Early in the first stage of labour, patients were nursed in the lateral position, with a maximum 20 degree head-up tilt, and as labour progressed, the head of the bed was gradually elevated to 45 degrees.

The nurse was instructed to turn off the infusion if the level of analgesia reached T6 (xiphysternal tip), if profound motor block developed in both legs, if hypotension (systolic blood pressure decrease greater than 30 torr or to less than 100 torr) was refractory to treatment with an intravenous bolus of 500 ml of fluid, or if the patient complained of dizziness or a tingling tongue.

If the patient complained of inadequate pain relief, supplementary top-ups, consisting of 6 ml 0.25 per cent bupivacaine for the first stage, were administered by the anaesthetist. The epidural catheter could be aspirated and a test dose injected through the side-port of the Intraflo without interruption of the infusion. The anaesthetist attended the delivery and, if required, supplemented the infusion with 10–12 ml of carbonated lidocaine, after which the infusion was turned off.

Clinical Study

The records of the first 187 consecutive patients were reviewed. Maternal age, height, weight, parity, and incidence of oxytocin stimulation were recorded, as well as the duration of labour, the duration of the second stage, the mode of delivery and the infant's weight.

The concentration of the infusion, the infusion time, and the number of patients who received additional top-ups for the first stage or for the delivery, were recorded. The total dose of bupivacaine administered to each patient during the infusion was calculated by adding the amount of any first stage top-up to the amount infused (concentration multipled by minutes of infusion). Profound motor block was considered to be present if the patient was unable to move her legs. Hypotension was defined as a decrease in systolic blood pressure greater than 30 torr, or to less than 100 torr. The number of patients in whom profound motor block or hypotension was observed during the infusion was noted, together with the maximum level of analgesia, and the necessity for bladder catheterization.

Data were analyzed for statistical significance using analyses of variance, Student's t test, chi-square analysis, and the normal deviate Z test where appropriate. A p value of less than 0.05 was considered significant.

Results

Of the 187 patients reviewed, 99 received 0.25 per cent bupivacaine (Group I), 49 received 0.30 per cent (Group II), and 39 received 0.375 per cent (Group III). Pure random selection of patients was not feasible because continuous epidural analgesia was not at that time routinely instituted. The epidural was requested if labour was prolonged or intolerably painful, in cases of inco-ordinate uterine

TABLE II Patient data (mean ± SD)

	Group I	*Group II*	*Group III*	*Total*
n	*99*	*49*	*39*	*187*
Bupivacaine concentration	*0.25%*	*0.30%*	*0.375%*	
Primipara	82 (83%)	36 (73%)	29 (74%)	147 (79%)
Oxytocin	64 (65%)	35 (71%)	27 (69%)	126 (67%)
Maternal age (yr)	24.9 ± 4.0	26.4 ± 5.3	25.7 ± 5.1	25.5 ± 4.6
Maternal height (cm)	162 ± 7	162 ± 5	163 ± 7	162 ± 7
Maternal weight (kg)	72.7 ± 9.6	72.8 ± 11.5	74.2 ± 11.3	73.1 ± 10.4
Infant weight (gm)	3451 ± 466	3306 ± 503	3519 ± 486	3425 ± 483

TABLE III Duration of labour, second stage and infusion time (mean ± SD)

	Group I	*Group II*	*Group III*	*Total*
n	*99*	*49*	*39*	*187*
Bupivacaine concentration	*0.25%*	*0.30%*	*0.375%*	
Duration of labour (hr)	10.84 ± 4.80	9.52 ± 4.43	8.89 ± 3.61	10.08 ± 4.53
Duration of second stage (min) (omits Caesarean sections)	65 ± 34 (n = 87)	63 ± 41 (n = 42)	54 ± 32 (n = 33)	62 ± 36 (n = 162)
Infusion time (min)	285 ± 154	248 ± 140	249 ± 158	268 ± 152

There was no relationship between dosage and parity. After accounting for parity there was no significant difference between groups. (Analysis of variance.)

action, or at the specific desire of the patient. This is reflected in the overall incidence of primigravida (79 per cent), but the groups were comparable in regards to parity, oxytocin stimulation, maternal age, height, and weight, and infant weight (Table II).

The duration of labour, second stage, and the infusion time, were significantly longer in primipara than in multipara, but after accounting for parity there was no significant difference between the three groups (Table III).

There was no relation between the mode of delivery (spontaneous, low forceps, mid forceps, or Caesarean section) and the concentration of the infusion (Figure 2).

The infusion alone provided adequate analgesia for both labour and delivery in only 38 per cent of patients in Group I, 41 per cent in Group II, and 51 per cent in Group III (Table IV). The infusion was supplemented by additional top-ups during the first stage in 30 per cent of patients in Group I, 10 per cent in Group II, and 13 per cent in Group III. This difference was significant between Groups I and II ($p < 0.01$), and I and III ($p < 0.05$), but not between II and III. There was no difference in the incidence of delivery top-ups (Caesarean sections excluded) between the three groups: 55 per cent in Group I, 64 per cent in Group II and 48 per cent in Group III. Thus, the infusion alone, or with the addition of only one top-up for delivery, was satisfactory in 70 per cent of patients in Group I, 90 per cent in Group II, and 87 per cent in Group III.

Hypotension developed during the infusion in one patient in each of groups I and III: in addition one patient in Group II and seven patients in Group III had profound motor block. The incidence of patients with such undesirable side effects of the infusion was significantly higher in Group III (21 per cent) than in either Group I (1 per cent) or Group II (2 per cent) between which the difference was not significant (Table V).

Mean dose per hour required to maintain adequate analgesia in each group is given in Table VI. Group I required a significantly greater amount (16.46 ± 0.30 mg/hr) than that delivered by the infusion i.e. 15 mg/hr.

The overall incidence of bladder catheterization, excluding patients who had Caesarean sections,

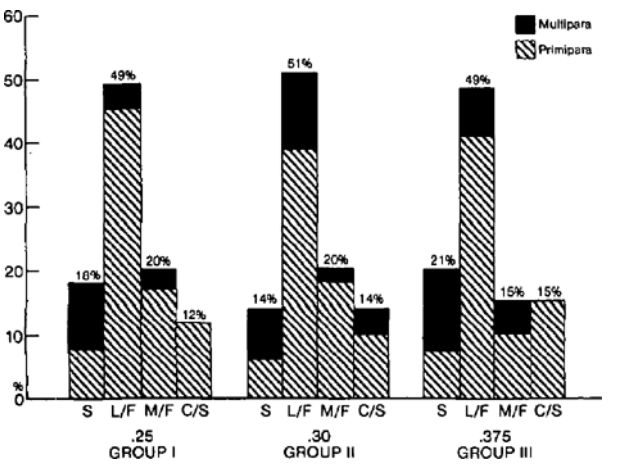

FIGURE 2 Modes of deliveries of patients in each group. S = spontaneous, L/F = low forceps, M/F = mid forceps, C/S = Caesarean section. There was no relation between the mode of delivery and the concentration of the infusion (Chi-square).

was 43 per cent and was unrelated to the concentration of the infusion. No block was recorded as going higher than T7.

Discussion

Procedures for topping-up continuous epidural analgesia are extraordinarily time-consuming. It is recommended that the catheter be aspirated before and after drug administration, that an effective test dose should precede each supplemental dose, that the latter should consist of small volumes of a low concentration administered as soon as pain returns, and that the patient be closely monitored for the next 20 minutes.[7] Top-ups may be delayed if the staff is busy, if there is failure to appreciate the rate of regression of analgesia,[8] or may be deliberately withheld in anticipation of the second stage.[9] Larger volumes of a more concentrated solution may be administered in an attempt to increase the interval between top-ups. Thus, maintenance by intermittent injection can result in fluctuating levels of analgesia or "roller-coaster anaesthesia," fluctuations in sympathetic tone and cardiovascular instability, and fluctuating maternal blood levels of anaesthetic. Maintenance by slow infusion has been used to provide continuous pain relief postoperatively,[10] and in obstetrics.[11,12] The advantages are: continuous analgesia, cardiovascular stability, minimal interference with motor function, less chance of contamination within a closed system, a reduced risk should intrathecal or intravascular injection occur, and, as fewer injections are given, there is less chance of incorrect dosage or drug administration.

The Intraflo 6 ml/hr continuous flush device affords a neat method to deliver the infusion. The Intraflo was originally designed to provide a catheter flush system for invasive pressure monitoring.[13] The concept of this device is simple: its essential component is a precision fine-bore marine glass capillary tube through which flow is laminar and obeys Poiseuille's law. The device is designed so that a pressure gradient of 300 mmHg results in a continuous flow of 6 ml/hr, with a range of 5–7 ml/hr. Since the flow is linearly related to the pressure gradient, the rate can be regulated to 6 ml/hr by adjusting the pressure of the infusor pump. Parallel to the capillary tube the Intraflo has a fast-flush channel sealed closed by a red rubber valve. The fast-flush valve only operates when actively held open by pulling on the valve stem, permitting the line to be flushed prior to use. Failure of the valve to close, resulting in a continuous fast flow, has been reported.[14] The manufacturer's

TABLE IV Efficacy of analgesia with continuous epidural infusion of bupivacaine at 6 ml/hr

	Group I	*Group II*	*Group III*
n	*99*	*49*	*39*
Bupivacaine concentration	*0.25%*	*0.30%*	*0.375%*
Infusion alone for first and second stages of labour*	38 (38%)	20 (41%)	20 (51%)
Top-up for first stage†	30 (30%)	5 (10%)	5 (13%)
Top-up for delivery* (cmits Caesarean sections)	48 (55%)	27 (64%)	16 (48%)
Infusion alone OR with top-up for delivery only†	69 (70%)	44 (90%)	34 (87%)

*No significant difference between groups.
†Difference significant between Groups I and II ($p < 0.01$) and I and III ($p < 0.05$), but not between II and III (normal deviate z test).

TABLE V Side effects of continuous epidural infusion of bupivacaine at 6 ml/hr

	Group I	*Group II*	*Group III*
n	*99*	*49*	*39*
Bupivacaine concentration	*0.25%*	*0.30%*	*0.375%*
Hypotension	1	0	1
Motor block	0	1	7
Number of patients	1 (1%)	1 (2%)	8 (21%)

There is no significant difference between Groups I and II, but the difference is significant between I and III ($p < 0.001$) and II and III ($p < 0.005$) (Chi-square).

TABLE VI Total dose of bupivacaine administered during infusion (mean ± SEM)

	Group I	*Group II*	*Group III*
n	*99*	*49*	*39*
Bupivacaine concentration	*0.25%*	*0.30%*	*0.375%*
Infusion dose (mg/hr)	*15*	*18*	*22.5*
Total dose (Infusion + first stage top-ups) (mg)	78.5 ± 4.4	77.3 ± 6.6	96.8 ± 10.1
Mean dose per hour (mg)	16.46 ± 0.30*	18.47 ± 0.21	23.09 ± 0.30

*Mean dose per hour administered to Group I was significantly greater than delivered by the infusion ($p < 0.001$) (Student's t test).

instructions specifically recommend that the valve stem be released with a snap to ensure proper closure of the valve, and that this be verified by observing the flow rate in the microdrip chamber. We cut off the valve stem sufficiently short, and in such a manner, that the end retracts within the plastic housing and cannot be used again. It is imperative to ascertain that the device is functioning correctly prior to connecting the pressurized infusion to the epidural catheter. Both patient and nurse should be aware of the importance of the slow rate of the infusion, and constant supervision is mandatory.

It is also essential that the epidural infusion line be distinct from any intravenous line, hence the microdrip administration set used for the epidural infusion is Luer-Lock and has no injection sites.

Intrathecal infusion should be suspected if the patient develops profound motor block in the lower body with an increasing level of sensory analgesia.

Intrathecal placement of the catheter can be confirmed by aspiration through the side-port of the Intraflo. Nolte has recommended 15–20 mg of isobaric bupivacaine for spinal anaesthesia,[15] and the slow infusion of an equivalent amount over an hour, would gradually produce a spinal block. This has been reported by Matouskova[16] and Kenepp[17]: in each case the infusions were stopped without incident. Intravascular infusion at this rate would be unlikely to produce signs of systemic toxicity,[18] but the analgesic effect would diminish, and the patient may complain of light-headedness or a tingling tongue. Intravascular cannulation can be confirmed by disconnecting the Intraflo and observing the catheter for the back-flow of blood. If none is seen, the catheter should be aspirated. If that too proves negative, a test dose of 3 ml of 2 per cent lidocaine with 1:200,000 epinephrine, injected intravascularly, should produce a 30 per cent increase in the patient's pulse rate.[19]

In our series, the total dose of bupivacaine administered during infusion, and the mean dose per hour with 0.25 per cent or 0.30 per cent at 6 ml/hr, are compatible with those reported by Reynolds and Taylor,[20] using an intermittent top-up technique, and by Evans and Carrie[21] who infused 0.25 per cent at 7–10 ml/hr. The prolonged infusion of 0.375 per cent bupivacaine at 6 ml/hr could exceed the maximum recommended dose.

The Intraflo is manufactured in three different flow rates: 3 ml/hr, 6 ml/hr and 30 ml/hr. A flow of 6 ml/hr provides adequate spread but satisfactory perineal analgesia may not be obtained if the patient is placed in the semi-sitting position too late. Similarly, if she is allowed to sit up too early, uterine analgesia may be unsatisfactory for the first stage.

There are other practical advantages of slow infusion epidural analgesia which deserve mention. The mother is never without some analgesia, as can occur with the top-up technique.[9] There is minimal interference with motor function, and she is able to turn herself, and to move from bed to stretcher. As the second stage approaches the continuous infusion reduces the uncontrolled urge to push prior to full dilatation. However, the bearing-down reflex is not entirely blocked, and as some pelvic floor tone is maintained, maternal expulsive efforts are more productive, and delay in the second stage is less likely to occur.[22,23] Many women regret being deprived of the sensation of giving birth,[24] and would prefer to accept some discomfort in the second stage in return for active participation and an increased likelihood of a spontaneous delivery.[25] Often, "natural childbirth" couples are willing to accept some analgesia, for the benefit of mother and foetus, as long as they are not totally deprived of the experience for which they have both prepared.[26]

Our obstetricians appreciate the flexibility the epidural infusion allows in the conduct of both labour and delivery, for additional anaesthetic can be easily administered as required. Our nurses are enthusiastic about this technique, although they accept that close supervision and constant vigilance of the patient is essential. If they are concerned about the infusion, they turn it off. The anaesthetist is responsible for the epidural, and for the instructions of those in attendance. In situations where only the anaesthetist can give epidural injections, the method permits him to visit the patient at convenient intervals, rather than being summoned the moment the pain returns. The importance of continuous supervision of the parturient by either a member of the health team or her support person, cannot be overemphasized.

Conclusions

We have found the method described by Davies and Fettes for continuous epidural infusion of bupivacaine through the 6 ml/hr Intraflo, modified by rendering the fast-flush valve inoperative, to be a practical technique for obstetric analgesia. In our experience 0.30 per cent bupivacaine combines the most effective analgesia with a minimal incidence of side effects. In spite of the constant supervision essential for the safe conduct of this technique, its adoption in this hospital has permitted the implementation of a satisfactory 24-hour obstetric epidural service which otherwise did not appear feasible.

Acknowledgements

The author wishes to thank the members of both the Department of Anaesthesia and the Department of Obstetrics at Scarborough Centenary Hospital for their co-operation over the past year. Special thanks are accorded the obstetric nursing staff. I am grateful to Statistical Consulting Service, University of Toronto, for undertaking the statistical analyses.

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Résumé

L'entretien de l'analgésie épidurale par infusion lente en obstétrique est une alternative possible aux injections intermittentes. La méthode, décrite par Davies et Fettes, utilisant 0.25 pour cent de bupivacaine passant dans un tube capillaire (Intraflo®) à 6 ml/heure avec la valve de flux hors d'action est simple et commode. Cependant on a observé un défaut dans la valve de flux, ce qui a résulté en un écoulement très rapide. Il est donc impératif, avant d'attacher le sytème pressurisé au cathéter épidural, de vérifier le bon fonctionment de la valve en vérifiant la vitesse de l'écoulement dans la chambre microdrip. Nous utilisons cette méthode depuis un an et nous avons trouvé ce dispositif efficace mais afin d'obtenir une analgésie satisfaisante nous avons augmenté la concentration de l'infusion à 0.375 pour cent initialement et nous l'avons ensuite réduite à 0.30 pour cent. Nous avons révisé les données chez les 187 premières patientes. Le Groupe I (n = 99) reçut une infusion de 0.25 pour cent de bupivacaine. Le Groupe II (n = 49) reçut 0.30 pour cent et le Groupe II (n = 39) reçut 0.375 pour cent. Significativement plus de patientes dans le Groupe I (30 pour cent) ont eu besoin d'une dose supplémentaire à l'infusion initiale durant le premier stage du travail que chez le Groupe II (10 pour cent) ou le Groupe III (13 pour cent). Une dose additionnelle fut ajoutée pour l'accouchement à 55 pour cent des patientes du Groupe I, à 64 pour cent du Groupe II et à 48 pour cent du Groupe III. L'incidence du bloc moteur était significativement plus élevée chez le Groupe III (21 pour cent) que chez le Groupe I (1 pour cent) ou chez le Groupe II (2 pour cent). Pour l'infusion épidurale continuelle à 6 ml/heure, 0.30 pour cent de bupivacaine a un effet optimum pour l'analgésie avec un minimum d'effets secondaires.