Abstract—This study assessed frequency, safety and efficacy of prehospital fentanyl analgesia during 6 months’ adult and pediatric helicopter trauma scene transports (213 doses in 177 patients). We reviewed flight records for pain assessment and analgesia provision, effect, and complications. Analgesia was administered to 46/49 (93.9%) intubated patients. In non-intubated patients, pain assessment was documented in 112 of 128 (87.5%), and analgesia was offered, or there was no pain, in 97/128 (75.8%). Of the 67 non-intubated patients to whom analgesia was administered, post-analgesia pain assessment was documented in 62 (92.5%) and pain improved in 53 (79.1% of 67). Post-analgesia blood pressure dropped below 90 torr in 2/177 cases (1.1%, 95% confidence interval [CI] 0.1–4.0%). Post-analgesia S\textsubscript{O}2 did not drop below 90% in any patients (95% CI 0–2.3%). In this study, prehospital providers performed well with respect to pain assessment and treatment. Fentanyl was provided frequently, with good effect and minimal cardiorespiratory consequence. © 2005 Elsevier Inc.

Keywords—fentanyl; prehospital; analgesia; helicopter; air medical transport

INTRODUCTION

The subject of prehospital trauma analgesia has received much attention, with most investigations suggesting that pain relief represents an area of potential improvement for Emergency Medical Services (EMS). In fact, most studies have found field analgesia provision rates under 25% for patients with conditions such as burns or isolated extremity fractures; one author reported that pain medications are administered in as few as 1.8% of cases (1–9). In reviewing this literature, authors have concluded that prehospital pain care leaves much to be desired, and have made the argument that pain relief is, in and of itself, an important endpoint for EMS (1,10).

The current study was undertaken for two reasons. First, we wished to assess the accuracy of an impression that our helicopter EMS program’s analgesia provision rates were substantially higher than those reported in the extant (primarily ground EMS) literature. Second, we noticed that, in a 2003 comprehensive review of prehospital pain management, the agent we use – fentanyl – was singled out both for its theoretical advantages and for the paucity of out-of-hospital evidence supporting its use (11). Therefore, we set out to assess and report both our program’s general performance with respect to pain as-
assessment and care and our specific experience with safety and efficacy of fentanyl.

Our protocols for trauma analgesia, which had long allowed for autonomous crew provision of opioids, were updated in 2003 to include requirements for flight crew assessment of pain levels as well as specific documentation of analgesic efficacy and safety. It was hoped that, if our analgesia protocols were found to result in safe and effective administration of opioids, the results would demonstrate a positive prehospital intervention with respect to an important outcome (pain reduction) and add to the body of literature supporting judicious use of fentanyl for trauma analgesia.

METHODS

The study was conducted by a transport service that provides trauma scene responses using four aircraft (three BK-117s and an AS365N2 Dauphin) in an urban region. The service provides approximately 2000 transports annually with a scene mission proportion of about 20% (virtually all scene flights are for trauma indications). Patients are transported to six adult and pediatric Level I centers. Human studies committee approval was obtained for the study.

This was a consecutive-sample trial that included all scene trauma responses occurring during the first 6 months of 2004. Flight crewmembers have always had authorization for autonomous opioid use in appropriate circumstances under the study programs’ patient care protocols. In 2003, the protocols were updated to indicate that: “fentanyl is the agent of choice for treatment of traumatic pain; administer 1–3 μg/kg per dose with maximum hourly dose of 7 μg/kg (in intubated patients) or 5 μg/kg (in non-intubated patients).” The protocols also state, “morphine (0.05–0.1 mg/kg every 15 minutes) is indicated for pain relief when a longer-acting agent is preferred and hemodynamic status is not at issue.”

The updated patient care protocols prioritize pain assessment and documentation, using either quantitative scales (e.g., a 10-point verbal analog score) or a qualitative scale with ratings such as “severe” and “moderate.” Flight crews are required to record patient response to analgesics, including both symptom relief and any side effects resulting from medications. Although air medical crews are advised to consider analgesia in all trauma patients, they are cautioned to use opioids judiciously. The current protocol states, “hypotension is much less of a problem with fentanyl than with other opioids, but any analgesic should be administered with caution in patients who are at risk for hemodynamic deterioration.” Crews may perform “repeated administration of analgesics as dictated by the clinical situation.”

The study included all scene trauma patients of all ages. Age categorization followed traditional, a priori-established cutoffs: adults were defined as those aged 18–55 years, with pediatric and older adult patients defined as those on either end of that range.

For much of our analysis, we grouped patients as to whether they were endotracheally intubated or not. In addition to being a coarse reflection of acuity, intubation (ETI) itself is usually facilitated with analgesics. Thus, we expected that analgesia rates would be close to 100% in intubated patients and did not wish to influence our pain care analysis by including a large subgroup with near-universal analgesia rates. Although we assessed the hemodynamic consequences of opioids in patients with endotracheal tubes, we restricted analysis of many other endpoints (such as degree of analgesia and pulse oximeter-indicated oxygen saturation $[SpO_2]$) to non-intubated patients.

Data collection for the study was performed by reviewing flight records to tally documentation of the parameters required under the trauma and analgesia protocols as described above. Notably, our program’s patient care protocols dictated prospective (i.e., at the time of transport) documentation of all of the information assessed in this study. Additionally, within 24 hours of all flights our crews execute telephone or in-person follow-up with receiving hospitals, with the goal of identifying patient status and developments; information routinely sought includes potential transport-related complications. This follow-up information, recorded in our flight records, was part of the information reviewed in this study.

In general, study endpoints were determination of the degree of adherence to our trauma analgesia protocols, and assessment of the benefits and adverse events associated with opioid administration. Specifically, we assessed the following: 1) Was pain assessed, and if so, how frequently and with what type of scale?; 2) What were the details (i.e., dose, agent, time) of analgesia administered?; 3) Was there an explanatory notation in cases where analgesia was not given, in cases where pain was documented or potentially present (e.g., suspected extremity injury)?; 4) Did analgesia administration result in reduced pain, and were pain scales used to assess medication response?; and 5) Were there any complications associated with analgesia administration?

Complications to analgesia administration were defined broadly. Our crews must document whether there were adverse or suspected adverse events associated with analgesia administration; charts were reviewed for this information. We further assessed for analgesia-related side effects by comparing systolic blood pressure (SBP) and $SpO_2$ pre-medication (i.e., within 1
minute before drug administration) vs. post-medication (first post-administration vital signs, 3–5 minutes after medication administration). Potential analgesia-induced hypotension was defined as occurring if post-analgesia SBP fell below 90 torr in a case where the pre-analgesia SBP had been above 90 torr. For pediatric patients, hypotension was defined as SPB less than $[70 + 2 \text{ (age)}]$. Hypoxemia was said to be potentially due to analgesia if the post-analgesia $S_O^2$ fell below 90% (in a non-intubated patient) if the pre-analgesia $S_O^2$ exceeded 90%. Consistent with previous prehospital study methodology, our documentation of the analgesic agent’s effects on SBP and $S_O^2$ focused on vital sign pairs bracketing analgesia administration (i.e., immediately preceding and approximately 3–5 minutes after medication administration) (12,13). Given the time course of fentanyl’s onset of action and maximal effect, the 5-minute post-analgesia time frame would be expected to capture adverse events (11,14–18). We also reviewed each chart for possible delayed complications (suspected either by crews or receiving hospitals).

Descriptive analysis was performed for assessment of endpoints such as the proportion of patients with documented pain levels or to whom analgesia was administered. Most safety endpoints (e.g., development of hypotension) were categorical and assessed descriptively, with generation of 95% confidence intervals (CIs) around incidence point estimates. Multivariate logistic regression using odds ratios (ORs) was employed to adjust for known covariates of importance (e.g., pain level) while assessing for pain assessment and care endpoints.

To ascertain whether medication administration caused changes in continuous variables such as SBP and $S_O^2$, the nonparametric sign-rank test was used. However, dichotomous categorical endpoints of pre- and post-analgesia SBP or $S_O^2$ drops (below 90 torr and 90%, respectively) were judged to be of greater clinical relevance than comparison of measures of central tendency.

Significance for all tests was set at the 0.05 alpha level. All statistics were calculated using Intercooled STATA version 8.0 (StataCorp, College Station, TX).

**RESULTS**

The study population comprised 177 patients, in whom flight crews administered 213 analgesic doses (205/213 [96.2%] fentanyl and 8/213 [3.8%] morphine). Patient characteristics are shown in Table 1.

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<th>Table 1. Characteristics of the Study Population</th>
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<td>Initial $S_O^2$ &lt; 90%</td>
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<td>Extremity injuries documented in flight record</td>
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**Results in Intubated Patients (n = 49)**

The study did not track pain assessment in intubated patients, most of whom (43/49, 88%) were intubated by flight crews. Of intubated patients, 46 of 49 (93.9%) received analgesia. The three intubated patients who did not receive analgesia from the flight crews had also not received analgesia from ground prehospital providers, although in one case benzodiazepine sedatives had been administered before air medical crew arrival. In the three cases where intubated patients did not receive analgesia, the patients had multiple injuries, including severe head injuries (Glasgow Coma Score [GCS] 3) and in two of the three cases there was no SBP recorded (but the patients were not pulseless). The third case, an 8-year-old with a severe head injury and no extremity injuries, was characterized by an SBP of 104; there was no specific documentation as to why analgesia was not given in this instance. In 10 patients with GCS of 3, fentanyl was administered.

**Documentation of Pain Assessment in Non-intubated Patients (n = 128)**

In the 128 nonintubated patients, 112 (87.5%) transport records described the patient’s pain with either a pain scale (66 cases) or narrative mention of pain presence or absence (62 cases). Of the 16 cases where pain was not addressed in the flight crew documentation, only 4 had suspected extremity injuries. Specifically analyzing patients with suspected extremity injuries, assessment of pain was documented on 61 of 65 (93.8%) patients. In the 4 cases with suspected extremity injuries but no
documentation of pain assessment, one chart mentioned analgesia “as needed.” In the other three cases, consideration of analgesia, or the reason for analgesia non-administration, was not addressed (although in two cases, hypotension may have contributed to analgesia withholding).

Multivariate logistic regression, incorporating an independent variable for “suspected extremity injury,” was used to assess whether pain assessment was more likely to be absent from flight records for men vs. women, or for older or younger patients vs. adults aged 18–55 years. Although the power of the regression was limited due to infrequent occurrence of the outcome of interest, no such associations were found. Pain assessment was no more likely to occur in men than women (OR 1.3, 95% CI .35–5.2, p = 0.71). As compared to adults aged 18–55 years, pain treatment was no more likely to occur in either older patients (OR 1.1, 95% CI .35–3.6, p = 0.86) or pediatric patients (OR .52, 95% CI .18–1.5, p = 0.22).

Documentation of Response to Analgesia Doses in Non-intubated Patients

As mentioned above, analgesia was offered to 74 patients in whom initial documented pain levels were nonzero. Seven refused analgesia, leaving a group of 67 patients who received at least one dose of pain medication (fentanyl in 63 [94%] with morphine in the remaining 4). In 62 of 67 cases (92.5%), the initial dose of analgesia was followed by documented qualitative or quantitative reassessment of pain; in 4 of the other 5 cases repeat analgesics were administered within 5–9 minutes. Thus, in only 1 of 67 (1.5%) cases of initial analgesia administration there was neither a documented pain reassessment nor timely analgesia readministration. In 53 of 67 cases (79.1%), initial analgesic dosing was documented by the flight crews to have produced good response (as noted either in the record’s narrative section or by qualitative or quantitative pain scales).

Complications from Analgesia (n = 213 Analgesic Doses in 177 Patients): Blood Pressure

Many of the 177 patients in the study received more than one analgesic dose. Overall, there were 113 first doses of medication, 67 second doses, 25 third doses, 5 fourth doses, and 3 fifth doses. Two patients received 3 doses each of morphine, and an additional 2 patients received single doses of morphine. Thus, in nearly all cases (96.2%), fentanyl was the analgesic of choice.

Blood pressure complications were assessed in all 213 instances of analgesia administration. There was no overall difference (p = 0.87) between pre-analgesia SBPs (median 136 torr, interquartile range 120–150) vs. post-analgesia SBPs (median 139 torr, interquartile range 120–151). The median interval between analgesia administration and post-analgesia SBP reassessment was 5 minutes (interquartile range, 5–6).

There were no blood pressure issues (pre- or post-fentanyl hypotension) in the younger pediatric patients. In older children (age at least 17 years) and adults, there were 8 cases in which the SBP taken after analgesia...
administration was below 90. Of those 8 cases, the post-
analgesia SBP was higher than the pre-analgesia SBP in
3 cases: 1) a 17-year-old with pre- and post-fentanyl
SBPs of 60 and 79 torr, respectively; 2) a 22-year-old
with pre- and post-fentanyl SBPs of 80 and 88, torr,
respectively; and 3) a 47-year-old with pre- and post-
fentanyl SBPs of 62 and 73 torr, respectively. In one case
a low pre-fentanyl SBP was unchanged after a dose of
fentanyl: a 61-year-old maintained SBP of 70 torr after a
single fentanyl dose, then the SBP rose within minutes to
122 torr and remained in that range during the remainder
of transport (during which time another dose of fentanyl
was given). Information is presented below on the 4 of
213 (19%) instances of analgesia administration where a
pre-analgesia SBP of at least 90 torr was followed by a
post-analgesia SBP of less than 90 torr:

- A non-intubated 30-year-old man with chest wall
injury (pain score 10/10), had a pre-analgesia SBP
of 101 torr, which dropped to 77 torr 5 minutes after
receiving an initial fentanyl dose of 100 µg (0.9
µg/kg). One minute later (6 minutes post-fentanyl)
his SBP was 81 torr and 3 minutes after that (9
minutes post-fentanyl) his SBP exceeded 120 torr.
His SpO2 remained 100%, and his subsequent SBPs
were unaffected by an additional 75 µg fentanyl
doses (2×).

- An intubated 63-year-old man with extremity inju-
ries including an open foot amputation, received an
initial fentanyl dose of 100 µg (0.8 µg/kg) without
complication. The SBP, 112 torr at the time of a
second fentanyl dose (of 150 µg, 1.25 µg/kg),
dropped to 86 torr 7 minutes later. A repeat SBP 3
minutes afterwards was 111 torr and he had no
further hypotension.

- An intubated 19-year-old with multiple trauma
(including grossly displaced lower extremity fractures)
received a total of 175 µg of fentanyl in two doses
without hypotension. At the time of his receiving a
third dose of 75 µg of fentanyl (1.1 µg/kg), the SBP
was 124 torr; the SBPs 5 and 10 minutes later were 86
and 96 torr, respectively. An additional 50 mcg of
fentanyl was then given and the following SBP (5
minutes later) was 125 torr.

- An intubated 17-year-old boy with severe head injury
(GCS = 4) and severe crush injuries (partial ampu-
tation of an entrapped leg) had SBP 90 torr before flight
crew arrival. He received fentanyl (100 µg, 1.1 µg/kg)
as part of rapid sequence induction with succinylcholine.
Within 3 minutes post-fentanyl, the SBP dropped
to 87 torr; subsequent SBPs 4 and 8 minutes post-
fentanyl were 89 and 97 torr, respectively.

Complications from Analgesia (n = 124 Analgesic
Doses in 67 Non-intubated Patients): SpO2

Respiratory depression, as assessed by a SpO2, was as-
essed in 124 analgesic doses administered to 67 non-
intubated patients. Of the 124 analgesia doses, paired
documentation of SpO2 both pre- and post-analgesia ad-
ministration was unavailable for 15 fentanyl administra-
tions in 14 patients. In 1 (normotensive) patient, SpO2
information was not assessable (probably due to cold
weather); this patient received 2 doses of fentanyl
and had no apparent untoward effects during or after trans-
port. In 8 patients (all normotensive), fentanyl was ad-
ministered at the time of landing at the receiving trauma
center and no post-analgesia SpO2 was recorded; pre-
analgesia SpO2 readings in these patients were 98–100%.
In 5 patients, there was no pre-analgesia SpO2 recorded,
but post-analgesia SpO2 values were noted (95–100%).

For the patients with SpO2 pairs, there was no change
between pre-analgesia (mean ± standard deviation,
99.6% ± .98) and post-analgesia (99.5% ± 1.2) SpO2
readings (p = 0.56). In no case was analgesia adminis-
tered to a non-intubated patient with SpO2 reading
less than 95%. In only 2 cases did post-analgesia SpO2 fall
below 95%; post-analgesia readings of 93% were noted
in patients in whom pre-analgesia readings were 95% and
93%.

DISCUSSION

This study’s findings of high frequencies of pain assess-
ment and treatment differ from results of other prehos-
pital analgesia investigations. A recent review of prehos-
pital analgesia identified noteworthy shortcomings such
as pain underestimation and low rates of administration
of appropriate analgesia (10). Underlining the impor-
tance of the topic, many authors have suggested that the
issue of prehospital pain relief represents a substantial
potential for EMS to have a positive impact on an im-
portant “outcome” for a large number of patients
(1,2,10). Given the fact that EMS providers frequently
encounter patients in pain – one survey found that 82%
of transported patients with suspected extremity fractures
had moderate-to-severe pain (2) – pain care should be an
important goal for quality prehospital care. With growing
emphasis on desirability of evidence-based approaches
for out-of-hospital care, the use of pain relief as an
outcome of importance is sensible and appropriate (1).

In addition to the humane imperative to relieve suf-
ferring, there are other reasons for relief of pain. Analge-
sia provision can blunt such pain-associated effects as
anxiety, cardiac dysrhythmias, and blood pressure eleva-
tion (which can be harmful in the head-injured)
Further, improvements in patient comfort and satisfaction, as demonstrated to result from better prehospital pain care, can increase patient cooperation and facilitate the diagnostic and therapeutic process (2).

An additional reason for encouraging administration of analgesia in the prehospital setting is the hectic nature of the Emergency Department (ED) and the associated problem of delayed pain care once EMS-transported patients arrive at the hospital. A previous air medical study found that only one-fifth of extremity fracture patients receiving prehospital fentanyl received any ED analgesia. Those who did receive pain medications had to wait a median 45 minutes (far longer than the expected clinical duration of action of fentanyl) after trauma center arrival (16). Another study, focusing on ground EMS-transported extremity fracture patients (who tend to be less severely injured than helicopter EMS transports) found a median time to analgesia of nearly 3 hours (3). Thus, the prehospital arena may represent a patient’s best chance for early pain relief, because even those with obviously painful injuries may not be destined for expeditious in-hospital analgesia (4,10,16). The practice of administering an analgesic dose at the time of arrival at the receiving trauma center, commonly executed by our flight crews (and likely other prehospital providers), highlights their awareness of the shortcomings of in-hospital pain care.

Despite the importance of prehospital analgesia, multiple investigators assessing rates of field analgesia provision have concluded that pain treatment is suboptimal. Although one prehospital study identified a 63% analgesia rate for patients with suspected extremity injuries (5), more typical reports have noted analgesia administration in only 1.8–19% of cases (1,4,7,8). The findings of previous investigators render noteworthy the current study’s finding that analgesia was offered to nearly 90% of patients with suspected extremity injury.

Why were analgesia rates in our study so high? There are many contributing explanations, but among the most important are a strong transport service emphasis on assessment and treatment of pain, and the associated flight crew familiarity that comes with over a decade’s experience with daily use of fentanyl in trauma patients. Pain was assessed in some fashion in nearly 90% of our non-intubated patients (and analgesia was given in virtually all intubated patients). Improvements in analgesia assessment correlate with improved pain care in the ED setting, and it seems likely that meticulous pain assessment is also salutary in the out-of-hospital setting (19).

The emphasis our flight program places upon pain care is reflected in protocols that serve as standing orders for pain medication. This study’s results, describing trauma patients receiving hundreds of doses of opioid analgesia with minimal side effects of consequence, demonstrate the feasibility of standing orders as a means to achieve safe and effective pain management. Standing orders are no panacea for the problem of inadequate prehospital pain management but they do reduce risks of medical control-related medication delays or refusals (1,4,5,7,10,20).

When opioid analgesia is appropriately administered in the prehospital setting, it tends to work well. For example, in a 2004 study assessing morphine analgesia use in patients with burns or fractures, pain relief was achieved in over 94% of medicated patients (8). Fentanyl also has been reported to be effective in air medical programs in the United States (in a series that included mostly intubated patients) and abroad (in small case series) (16,20). Given the benefits of opioid analgesia, attention logically turns to questioning why pain medication may not be a good idea.

Analgesia interferes with the mental status examination in head-injured patients, and in fact, recent guidelines from the National Association of EMS Physicians expressly state that analgesia should not be administered to patients with head trauma (21). Because most trauma patients for whom air transport is requested (e.g., in the setting of motor vehicle crashes) have at least potential head injury, judgment is required to balance risks of analgesia-induced mental status change or hypotension against benefits of reducing pain. Though overly aggressive analgesia has risks, severe pain (with its attendant psychological and physiologic changes) also poses risks for the head-injured, which is why opioid analgesia is a part of some (French) head-injury care protocols designed by trauma anesthesiologists (15). Although the controversy will not soon be resolved, and case-by-case judgment is warranted, it seems unlikely that universal withholding of analgesics from those with potential head injuries represents the optimal approach.

If there are rational arguments underlying analgesia withholding in the head-injured, other frequently encountered justifications for non-administration of pain medication are less compelling. For example, extant literature suggests administration of opioids has been associated with little risk of clinically significant hypotension, hypoxemia, or (in fewer studies) hypoventilation as assessed by monitoring of end-tidal carbon dioxide (8,9,12,13,16,22–25). Another concern, interference with the physical (particularly abdominal) examination, has been invoked to justify withholding of pain medication in acute trauma (14). Although it is reasonable to be judicious in analgesia (e.g., by giving lower doses or a short-acting agent) in patients in whom the physical examination is critical, it should be noted that prescriptions against analgesia for non-trauma abdominal pain are more theoretical than practical, are likely incorrect,
and certainly have not been validated in trauma patients (26,27).

Most commentators addressing the subject have judged that the extant literature, although imperfect, justifies administration of prehospital analgesia in at least some cases (10,26,28,29). The consensus is that analgesia can reduce (though not necessarily aim to eliminate) pain while maintaining an acceptable safety margin through a combination of judicious medication administration, maintenance of low thresholds for diagnostic imaging, and (in unusual cases) use of naloxone.

Typical doses of morphine seen in both prehospital studies and guidelines for EMS care, are 2–5 mg for adults and 0.1 mg/kg for children (7,26). In the 8 administrations of morphine in our study, 4 mg was given in 7 cases and an 8-mg dose was given in the other instance. The EMS for Children (EMS-C) partnership’s model pediatric protocols, citing morphine’s safety and efficacy demonstrated by extensive experience in injured children, call for morphine use in a dose of 0.1 mg/kg (maximum dose of 10 mg) (26).

Fentanyl, which does not release histamine and therefore is associated with minimal risk of hemodynamic depression, is frequently mentioned as possessing characteristics useful in the prehospital arena (13,15,16,20,22,23,26,30–32). Additionally, fentanyl’s pharmacological profile means it is easier than morphine to titrate, and thus arguably entails less risk of respiratory depression because the more rapidly acting agent can be better dosed to effect (11). The doses of fentanyl reported in available series are well under the range expected to entail significant risk of side effects (e.g., dorsal motor neuron-mediated chest wall rigidity) (16). The generally recommended dose ranges are 1–3 μg/kg per dose in adults and children (26).

Our design and results are limited by a number of shortcomings. First, though the documentation parameters we assessed were “required information,” as dictated in prospective fashion in our program’s patient care protocols, our retrospective chart review remains an indirect assessment of outcomes of interest. Because having an additional person ride along on transports to assess pain management is impractical from both logistic (e.g., aircraft weight and balance issues) and methodological (e.g., Hawthorne effect) perspectives, it is not easy to conceive of a workable, non-retrospective mechanism for evaluating prehospital pain care. On the other hand, the low feasibility of a nonretrospective methodology does not mean that the drawbacks to our study design should be ignored.

A second study shortcoming, of particular relevance to the comparison of this study’s pain care results with those of other (ground) prehospital investigators, is that our patients likely differed from those in most ground EMS cohorts. As a helicopter transport service, the study program tends to be called for patients of higher acuity than that of patients comprising much of the ground transport pain literature. Therefore, some of the explanation for higher analgesia rates may be related to air transported patients having extremity injuries that are simply more painful. Realistically, it seems unlikely that this would significantly confound comparison of two groups of patients with suspected extremity injuries, and the large disparity between our results and those of other investigations is not easily attributed to differing pain levels. If anything, patients of lesser acuity are more likely to have isolated extremity injuries, and thus even less reason for non-administration of analgesia (assuming EMS services have protocols allowing such medication).

Our assessment of analgesic efficacy was, considered in quantitative terms, somewhat disappointing. Although we planned to assess quantitative endpoints such as verbal analog scores, we found that paired (pre- and post-analgesia) 10-point scales were available for a minority of our patients. Instead, crewmembers often used “non-standard” pain scales that accurately reflected pain decrement (e.g., “+++” to “+”) but could not be translated (i.e., for analysis) into 10-point scales. Quantitative analysis was further restricted by the common occurrence of pre- and post-analgesia pain levels being assessed in purely qualitative fashion (e.g., “severe” to “a bit”). As a result of this study, we have further emphasized to our flight crews the importance of quantitative pain tracking.

In assessing vital signs pairs bracketing opioid administration, we may have missed complications resulting from analgesia administration. This methodology has been used in the past, but it is admittedly imperfect on a number of fronts—most importantly the potential for missing respiratory or hemodynamic compromise due to timing of vital signs assessment (12,13). However, the time parameters of fentanyl (the rare uses of morphine were unassociated with any potential complications in this study) are well-characterized. Additionally, the chart reviews for both the transport and early post-transport period (as assessed by our routine follow-up) were broadly focused. Regardless, the possibility remains that there was undetected hemodynamic compromise. The clinical consequences of such compromise are difficult to calculate, but it should be kept in mind that sequelae of any brief hypotensive periods missed by our analysis should be considered as potentially counterbalanced by the benefits of pain relief. In fact, the principle of pain relief is deemed sufficiently important that our air medical program’s fentanyl protocols do not include a specific proscription against opioid administration in patients with a SBP below a certain number. In most cases.
when patients are hypotensive, lower-range fentanyl dosing is administered (see next paragraph) or fentanyl may even be withheld. However, in our opinion, air medical crews have been able to use clinical judgment and incorporate a number of factors (e.g., patient’s level of distress, known baseline SBP, reliability of SBP assessment) into a decision as to whether analgesia should be provided. The decision to administer opioids to trauma patients with documented SBPs of less than 90 torr is not taken lightly, and fentanyl is not given frequently to hypotensive patients, but we think that prohibition of analgesia in every case where recorded SBP falls below 90 torr isn’t necessarily in patients’ best interests.

As another potential study shortcoming, if “low-dose” fentanyl is being regularly used, then side effects would be less likely seen than would be the case if all patients received the 1–3 µg/kg called for in our air medical program’s protocols. This would be especially problematic if our study’s failure to identify problems from fentanyl was only because subtherapeutic dosages were utilized. In fact, there were 24 cases (none of which was characterized by hypotension) where patients’ initial fentanyl doses were less than 1 µg/kg. In 14 of these cases the fentanyl dose, as calculated based upon estimated weights (that of course are not necessarily accurate) was at least 0.8 µg/kg. In these instances, the “under-dosing” was probably related to the logistics of drug administration and the crew’s tendency to administer fentanyl in aliquots divisible by 25 µg. In the remaining 10 cases (where the initial fentanyl dose was less than 0.8 µg/kg), some pain relief was documented in 7 instances (in the other cases post-analgesia pain levels were not recorded). In those 10 cases where initial fentanyl dosing was less than 0.8 µg/kg, 9 patients received at least one repeat fentanyl dose within minutes; crews may have intended to “split” the fentanyl dose into multiple aliquots. In any event, it seems unlikely that fentanyl “under-dosing” translated into a situation where apparent safety of pre-hospital analgesia was mistakenly inferred due to the administration of inadequate amounts of pain relief.

Pulse oximetry is an incomplete assessor of respiratory depression; carbon dioxide monitoring would have been preferable to assess for occult hypoventilation in non-intubated patients. In fact, we believe that this is an issue worthy of close scrutiny, and our flight program is moving towards routine carbon dioxide monitoring in non-intubated patients. In a preliminary analysis, though, fentanyl administration in the air medical setting has been found to be unassociated with respiratory depression as assessed by carbon dioxide monitoring (25). Our program is continuing with experimental use of carbon dioxide monitoring and in the future we plan to report our experiences with this modality as an indicator of early or occult respiratory compromise.

In conclusion, despite study weaknesses and identification of areas for further clinical improvement, our prehospital program performed well with respect to pain assessment and treatment. Results were favorable in a manner that suggests that air medical crews called to trauma scenes can safely and effectively treat pain with fentanyl. Because we agree with others who believe that pain care is an important EMS endpoint, the results of this study make a compelling argument that our air medical program’s practice of providing fentanyl analgesia to injured patients engenders minimal risk and positively impacts outcome (1,2). Future studies should 1) refine the search for undetected sequelae, 2) focus on means of improving and standardizing pain assessment, and 3) elucidate—and assess exportability of—reasons for our air medical crews’ provision of analgesia at rates so much higher than those reported by ground EMS.


