



BRIEF REPORT

Pain Management with Inhalation of Methoxyflurane Administered by Non-Medical Ski Patrol: A Quality Assessment Study

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ABSTRACT

Introduction: Pain management can be challenging, especially in remote locations where first responders are not certified health care personnel. In these settings, traditional intravenous administration of analgesics is not feasible. In this study, we explore the feasibility of using methoxyflurane as a first-line analgesic in ski-related traumas, administered by the ski patrol, acting as the municipality physician's aiding personnel.

Methods: This is a quality assessment of a project aimed at improving pain management in trauma patients at the largest ski resort in Norway. Members of the ski patrol were trained and

delegated administration of methoxyflurane on behalf of the municipality physician. Patients > 18 years with ski-related trauma and pain Numeric Rating Scale (NRS) of 6 or more were included. The patients received inhalational methoxyflurane on site, with continued administration during transport. Data were collected by the ski patrol and entered into a quality register.

Results: In total, 53 patients (18 to 76 years, 32 (60%) males) accepted to be registered. The injuries were fractures in 35 (66%), joint luxation in seven (13%), combination of fracture and luxation in seven (13%), and blunt soft tissue damage in four (8%) cases. Median NRS before administration of methoxyflurane was 8 decreasing to median NRS 5 after 5–10 min. The median NRS reduction of 3 (25–75% percentiles 2–5) was significant, $p < 0.001$. Patients rated the perceived effect as good in 40 (80%) moderate in nine (18%) and no effect in 1 (2%). Side effects were mild: Six patients (11%) experienced dizziness, one patient (2%) was considered drowsy.

Conclusions: Methoxyflurane is feasible as a first-line analgesic administered by a non-medical ski patrol in a responsibly organized system. Early pain management with inhalation of methoxyflurane provides good perceived effect with mild adverse events and can be of great value in settings where few alternatives for pain management are available.

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Key Summary Points

The acute treatment of moderate and strong pain is difficult for non-medical first responders.

Adequate pain management is important to be able to transport the patient from an austere environment to health care resources.

Inhalation of methoxyflurane seems to be feasible as an analgetic administered by non-medical professionals in austere environments.

Non-medical professional administration of potent analgetic agents requires a sound and responsibly organized system with clear delegations and access to medical advice.

INTRODUCTION

Pain management after trauma can be a challenge in the prehospital setting [1]. This is especially true in remote locations where health care personnel (HCP) are not readily available. Trauma incidents in alpine ski resorts pose challenges for ambulance services as they are not easily accessible. In such cases, the patient must be transported to the ambulance by ski patrol personnel. Such downhill alpine transports are often performed by sleigh and the transport can be uncomfortable. Thus, proper analgesics administered on site is important to avoid unnecessary pain and improve the conditions for transportation.

Most ski patrollers are not certified HCP, hence they are not certified to administer potent analgesia to patients [2]. In addition, ski resorts are not healthcare providers and cannot themselves delegate medical procedures but rely on assistance from health care providers.

For efficient pain management, the intravenous and intramuscular routes would be preferable but are not feasible because they require skills and certification. In addition, the intravenous route is time-consuming. The oral route takes time for an effect, and rectal administration is not suitable in an alpine setting. Intranasal fentanyl administered by ski patrol has been studied [3] with promising results, but requires a certain level of medical knowledge and monitoring of the patient. In general, time-consuming treatments must be carefully weighed against the risk of delaying transport and treatment of the injury [4, 5].

Methoxyflurane is a volatile fluorinated hydrocarbon inhalation anesthetic with analgesic properties in sub-anesthetic dosages. It is easy to administer via a hand-held whistle-shaped inhaler and has demonstrated analgesic effect superior to placebo for acute pain relief [6]. Methoxyflurane has a good safety profile [7, 8] and is widely used as an inhalational analgesic in adults [9] and children, with decades of experience from Australia and New Zealand [5, 10, 11]. The European license for methoxyflurane covers emergency relief of moderate-to-severe pain in conscious adult patients with trauma-associated pain [12]. The patient self-administers the medicine by holding the inhaler like a smoking pipe. The effect depends on continuous inhalation and the effect ceases when inhalation pauses. The most prominent side effect is drowsiness, but this is self-limiting because reduced consciousness will pause inhalation when the pipe is no longer actively held in the mouth with the lips sealing around it. It is therefore considered safe for the patient to use methoxyflurane in a setting where close monitoring is difficult [13]. Hence, we wanted to explore the feasibility of using methoxyflurane as a first-line analgesic in ski-related traumas, administered by the ski patrol.

The aim of this quality assurance study was to analyze the use of methoxyflurane in the hands of non-medical professionals in a ski resort where the patient had no access to the health care professionals before evacuation by the ski patrol. The objective was to collect data on patients' characteristics, trauma categories, pain reduction, satisfaction, weather

conditions, and side effects. We also wanted to explore the legal aspects of delegating administration of analgesics to ski patrols acting as aiding personnel to the local medical center.

METHODS

This quality assurance study was initiated by the municipality physician in Trysil to improve the pain management in trauma patients from the ski resort. It was a collaboration between the local municipality, the prehospital services of Innlandet Hospital Trust, and the company SkiStar. SkiStar owns and operates Trysil Ski Resort, the largest ski resort in Norway with 31 lifts and 68 (78 km) alpine slopes. The ski patrol is a non-medical service in the company SkiStar.

Norwegian health regulations state that certified health care personnel (HCP) can use aiding personnel in their profession if organized responsibly, and if the competence required for the task is ensured [14, 15]. After a clarifying dialogue with the Norwegian Directorate of Health, a preordained procedure was developed to ensure proper criteria for the use of the drug by the ski patrol. The participation for ski patrollers was voluntary, but required 3 years of experience in the service, and minimum 80% position to ensure continuity and suitability. The ski patrollers participated in a training course with focus on pain score, indications of pain management, contraindications of methoxyflurane, documentation, consent, confidentiality, and safety prior to being delegated administration of methoxyflurane on behalf of the municipality physician and local medical center.

Inclusion criteria for the patients selected were ski-related trauma, pain Numeric Rating Scale (NRS) of 6 or more and age > 18 years. Exclusion criteria were any contraindication to methoxyflurane according to the Summary of Product Characteristics (SPC) [12], and if the patient did not want to receive methoxyflurane.

The ski patrollers assessed patients with ski-related trauma according to the inclusion criteria and informed the patient about the procedure. Based on an oral consent, the patient was given the methoxyflurane device

(Penthrox®; Galen Ltd) and was instructed by the ski patroller on how to use it. The administration was initiated on site and continued during transport with as little time spent on site as possible. The main endpoints were changes in NRS from before to 5–10 min after start of treatment, and perceived effect by the patients. Other data were used to describe the setting. Data were documented on a form: NRS prior to administration, 5–10 min, and 30–60 min after start of methoxyflurane inhalation; timeline; number of doses; patient characteristics; type of injury; weather conditions; adverse events; observed and perceived effect.

The data forms were consecutively collected by the local responsible physician. Data were plotted in Microsoft Excel version 16 (Microsoft Corporation. Retrieved from <https://office.microsoft.com/excel>) and imported to IBM SPSS Statistics for Windows, Version 28.0. (IBM Corp, Armonk, NY, USA) for statistical analyses. The NRS and wind variables were not normally distributed (tested with Shapiro–Wilk test), and hence non-parametric tests were applied. Differences in NRS were analyzed with related-samples Wilcoxon signed-rank test.

This study is defined as a quality assessment study and approved by the Data Protection Officer at Innlandet Health Trust with reference number 973254. It is not considered a clinical trial, and hence ethics committee approval was waived, and patient consent was not needed. However, patients were informed about the data collection, and gave oral consent to be registered in the quality database.

RESULTS

The study was performed during three ski seasons, from 2019 to 2022. In total, 53 patients were included, of which 32 (60.4%) were males (see Table 1). Median age was 42 years (range, 18–76 years), with no difference between genders. Median ambient temperature was -3°C (25–75% percentiles -7 to 0°C), and median wind velocity was 2 m/s (25–75% percentiles 0–3 m/s). Median time the ski patrol spent on site before evacuation was 10 min (25–75% percentiles, 5–11 min). Most of the patients

received one dose of methoxyflurane, only six (11%) patients were given two doses.

The injuries were fractures in 35 cases (66%), joint luxation in seven cases (13%), combination of fracture and luxation in seven cases (13%), and blunt soft tissue damage in four cases (8%). The injury was located to the upper extremities in 29 cases (55%) and lower extremities in 18 cases (34%), one with trauma in both upper and lower extremities.

Median NRS before administration of methoxyflurane was 8 (25–75% percentiles 8–9) decreasing to median NRS 5 (25–75% percentiles 4–6) after 5–10 min. The median NRS reduction of 3 (25–75% percentiles 2–5) was significant (related-samples Wilcoxon signed-rank test), $p < 0.001$, Fig. 1. There was no gender difference in NRS reduction. NRS was also assessed in 30 patients after 30 to 60 min, and it remained with a median of 5 (25–75% percentiles 4–6) (see Fig. 2). However, seven of those patients had at 30 min received other medications from the ambulance service, hence the effect was not solely based on methoxyflurane. Of the 50 (94%) responses, the patients rated the perceived effect on a three-level Likert scale; 40 (80%) stated good effect, nine (18%) stated moderate, and only one (2%) stated no effect (see Fig. 3). This response corresponded exactly to a similar Likert scale where the ski patrollers rated their impression of the patient effect.

The ski patrollers were asked whether the patient seemed to receive instructions regarding the administration of methoxyflurane easily. Although the response rate was only 62%, the answers confirmed that the patients were easy to instruct.

Side effects were mild: six patients (11%) experienced dizziness, one patient (2%) was considered drowsy.

A system where non-medical personnel is delegated the administration of prescription drugs needs to be legally sound. This was arranged with a preordained procedure where the prescriber stated the criteria for use, and where the personnel went through formalized qualifying training. The tight collaboration between the medical center and the ski patrol enabled the municipality physician to appoint

Table 1 Patient characteristics and outcome

Gender	<i>n</i>	%
Males	32	60%
Age (years, median and range)	42	18–76
Types of injury*		
Fracture	42	79%
Joint luxation	14	26%
Soft tissue injury	4	8%
		25–75%
Numeric Rating Scale (NRS)	Median	Percentiles
NRS before methoxyflurane administration (<i>n</i> = 53)	8	8–9
NRS 5–10 min after initiation of methoxyflurane (<i>n</i> = 51)	5	4–6
Change in NRS from before to 5–10 min (<i>n</i> = 51)	3	2–5
NRS 30–60 min after initiation of methoxyflurane (<i>n</i> = 30)**	5	4–6
Perceived effect of methoxyflurane (<i>n</i> = 50)	<i>n</i>	%
No effect	1	2%
Moderate effect	9	18%
Good effect	40	80%
Side effects	<i>n</i>	%
Dizziness	6	11%
Drowsiness	1	2%

*Some patients had more than one injury; hence total percent add to more than 100%

**Seven patients also received other analgesics before the 30 to 60-min NRS

the named ski patrollers to act as aiding personnel for the physician, and hence to administer methoxyflurane according to the agreed procedure. The ski patrollers had the direct telephone number to the municipality physician in case of any unforeseen matters. No

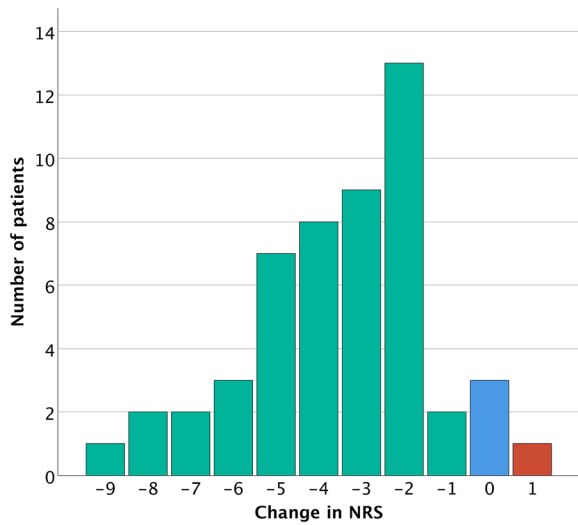


Fig. 1 Change in pain Numeric Rating Scale (NRS) from before to after treatment

events occurred where the presence of the municipality physician was required.

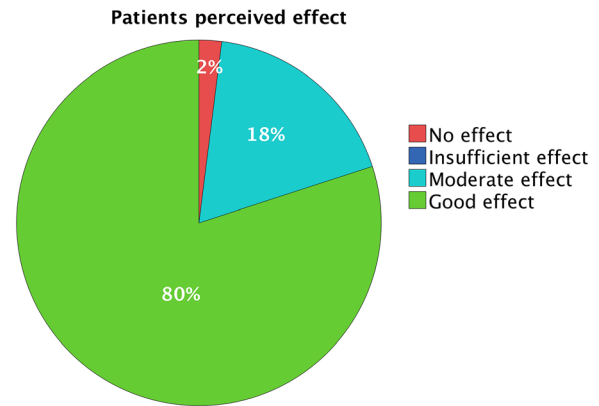


Fig. 3 Perceived analgesic effect by the patients

DISCUSSION

This quality assurance study shows that it is feasible to delegate administration of methoxyflurane inhalation to non-medical professionals such as ski patrols. Delegating medical treatment to non-medical professionals has both legal and ethical implications. The

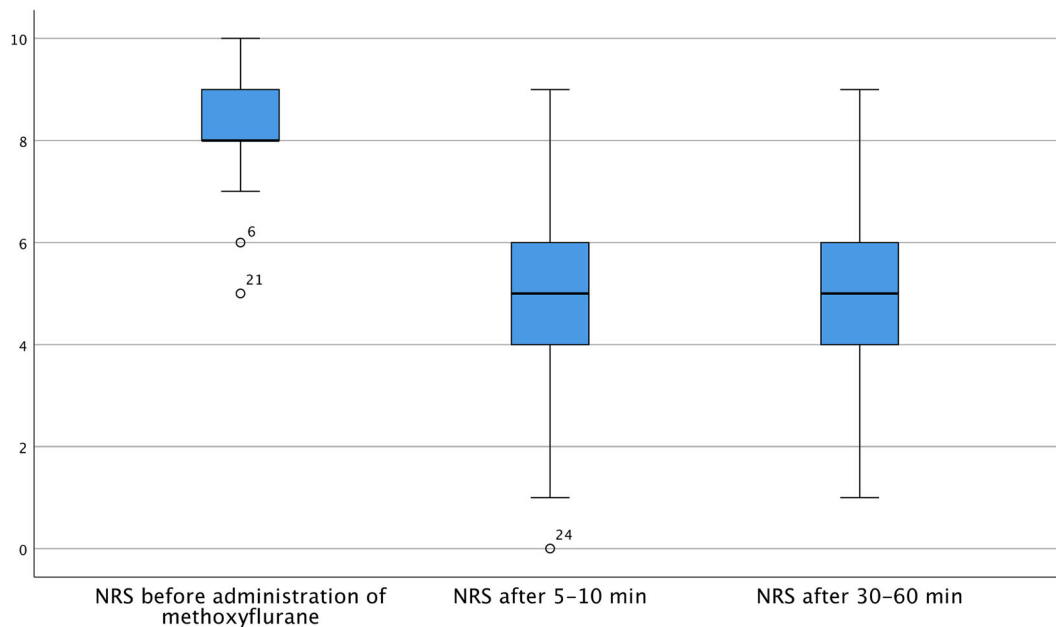


Fig. 2 Numeric Rating Scale (NRS) before and after initiation of methoxyflurane. All patients ($N = 53$) had NRS assessed before (median NRS = 8) and 5–10 min after initiation of treatment (median NRS = 5). Thirty

(57%) of the patients also had NRS assessed 30–60 min after initiation of treatment (median NRS = 5), however some of these patients had also received additional analgesics

prerequisite is a legal framework where the ski patrollers are acting as aiding personnel for the responsible physician after sound training programs and development of standard operating procedures (SOPs). Such arrangements must follow national legislation, and will hence vary between countries. Independent of the legal status, the ethical aspects require that the system with the non-medical professional at the patient's side, and the remote responsible physician together can handle any event caused by the treatment.

This study showed a clinically and statistically significant reduction in NRS 5–10 min after initiation of methoxyflurane administration. Although the median NRS remained elevated and with patient still in need for additional analgesics, the reduction from high (median NRS 8) to moderate (median NRS 5) pain score is of great value in a situation with few other safe alternatives for managing acute traumatic pain. Most patients experienced good or moderate effects of the treatment. The side effects were expected and mild, and there were no events requiring a physician on site.

A statistically significant pain reduction is not necessarily clinically relevant if pain relief is not perceived. In postoperative acute pain, Cepeda et al. showed that for moderate pain, “minimal” improvement of pain needed a decrease in NRS of 1.3 units, and “much” improvement was achieved with a decrease in NRS of 2.4 (35% reduction), while with severe pain, a corresponding “much” improvement needed a decrease in NRS of 3.5 units (45% reduction) [16]. Similarly, for cancer-related breakthrough pain, an adequate relief in pain was achieved by optimal sensitivity/specificity-cut-off when the change in pain intensity score was > 33% [17]. Pain and pain relief are perceived differently in different settings and with different pain mechanisms. Our patients had all acute trauma-related pain. Although the median NRS after treatment was high, the median reduced NRS of three units corresponded to the clinically meaningful reduction in pain referred to above, which was also reflected by the perceived effect where 80% stated good and 18% moderate effects.

The pain reduction from median NRS 8 to median NRS 5 also corresponds to other European studies where methoxyflurane is used for prehospital pain management, and with similar median initial NRS [18, 19]. These studies were performed by trained ambulance workers in Austria and Sweden, respectively. Interestingly, our study shows a similar clinical effect when administered by non-medical ski patrollers in an alpine setting. Pain reduction to enable the transport of ski trauma patients is important, and in this context, the initial transport off the slope can be considered as a necessary but painful procedure. A British review concluded that inhaled methoxyflurane is an attractive alternative to standard sedation techniques for outpatient procedures, especially in patients at risk for sedative complications [13]. Although our clinical experience is that the most severe injuries with high NRS require administration of more potent analgesics, methoxyflurane has a role in the initial phase where no alternative analgesics are available.

According to the SPC [12], methoxyflurane can be stored in low temperature, which is of value in the alpine setting. The median temperature in this study was $-3\text{ }^{\circ}\text{C}$. The simple and swift administration is an advantage, and the patient can start inhalation within a few minutes after arrival of the ski patrol in all weather conditions. A short time on the scene (in our study, the median was 10 minutes) is crucial for reducing the risk of hypothermia. The time-efficacy of methoxyflurane is also described in a report by Young et al. [20] with 71 min shorter time in emergency department (ED) for patients who received treatment with methoxyflurane. The self-titration by the patient was especially useful for missions in difficult terrain and during transport in a rescue bag. This quick approach is also of value to other prehospital providers [18, 21].

Our study did not uncover any severe adverse events, which is in accordance with the studies from Sweden and Austria [18, 19]. However, our study is not designed to detect severe complications. Nevertheless, the overall experience with methoxyflurane is that the drug is safe to use in low doses and with short-term use [6, 9, 19, 21]. The safety profile and

effectiveness used by a non-medical ski patrol opens the possibility to improve trauma treatment and pain management early in the chain of acute trauma handling. These first responders work with limited time and competence of analgetic treatment.

We consider methoxyflurane to have a good safety profile, but it is important to recognize situations where special caution should be taken, for example where the risk of aspiration is elevated, when other reasons for reduced consciousness are evident, and where the strong odor might be an issue. Thus, we experienced that close contact between prescriber, ski patrol, and local prehospital care providers is essential, and must be organized carefully and within the healthcare regulations.

This is not an efficacy or a safety study, and we do not compare the effect to other analgesic agents. Although we found a statistically significant pain reduction in our sample, the rather small number of patients means that one should be cautious in generalizing to a larger population, for which a proper controlled trial is needed. This is solely a quality assessment and feasibility study, and the findings are based on observations made by non-medical personnel, with inherent limitations. Nevertheless, the personnel were thoroughly trained and instructed to follow the procedures and fill out the forms. We therefore believe that both the pain scores and the observations are of good quality.

Future studies on the prehospital administration of methoxyflurane could also focus on other non-medical mountain patrols, other non-medical first responders, or participants in remote high-altitude expeditions (4, 22, 23). Randomized controlled trials in the pre-hospital setting to compare methoxyflurane to other well-known substances such as IV morphine or IN fentanyl will also help to inform decision-making for pain therapy strategies in austere environments.

CONCLUSIONS

Methoxyflurane is feasible as a first-line analgesics administered by a non-medical ski patrol

in a responsibly organized system where the ski patrol personnel are delegated the administration according to a preordained procedure after thorough training, and the municipality physician takes the medical responsibility. Early pain management with inhalation of methoxyflurane provides good perceived effect with mild adverse events and can be of great value in settings where few alternatives for pain management are available.

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Author contributions. HSR and LOF initiated the study and drafted the first protocol. HSR established the quality database and collected the clinical data. FH performed the statistics. FH and LOF analyzed the data. FH structured the manuscript and all authors contributed in writing the manuscript. All authors read and approved the final manuscript.

Disclosures. The authors declare that they have no competing interests.

Compliance with Ethics Guidelines. This study is defined as a quality assessment study and approved by the Data Protection Officer at Innlandet Health Trust with reference number 973254. It is not considered a clinical trial, and hence ethics committee approval was waived, and patient consent was not needed. However, patients were informed about the data

collection, and gave oral consent to be registered in the quality database.

Data Availability. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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