

USE OF A EQUIMOLAR MIXTURE OF NITROUS OXIDE AND OXYGEN IN THE PAIN MANAGEMENT OF PEDIATRIC PATIENTS – OWN EXPERIENCE AND REVIEW OF LITERATURE

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Abstract

Pain is one of the most common causes for consultation of a paediatrician and represents a major problem in paediatrics. Simple self-reporting and behavioural pain scales are suitable for assessment of intensity of acute pain. Acute pain of whatever origin should be treated immediately. The high analgetic, anxiolytic and sedative effects of nitrous oxide have been known worldwide for a very long time, but the inhalative administration has been approved in our country only in the early beginning of 2011 (authorization number 3143/2011) [1]. The principle of an anxiety and pain-free treatment necessitates, particularly in childhood, a standardized age-related pain management. The oral, rectal or i.v. administration of a sedative/analgesic in pediatric surgery is mostly accompanied by a great deal of stress for all involved and the alternative of general anesthesia is often not readily available or even not available at all. Nitrous oxide is a good alternative to the other mentioned methods for pain management in the pediatric patient. It is absorbed and eliminated through the lungs and because metabolism does not take place in the body fasting is unnecessary. Side effects may occur, but are completely reversible at the end of the application.

Keywords: Children. Pain. Anxiety. Nitrous oxide. Trauma. Pediatric surgery.

Introduction

The principle of an anxiety and pain-free treatment is particularly in childhood a very big challenge for all persons involved: patient, parents and medical staff. A standardized age-related pain management is needed. The presence in to the unknown environment of the hospital triggers the fear in the mind of a small child. Also a painful diagnostic or therapeutic maneuver will remain for a long time as a horrifying experience [2,3,4,5]

The oral, rectal or i.v. administration of a sedative/analgesic in pediatric surgery is mostly accompanied by a great deal of stress for all involved and the alternative of general anesthesia is often not readily available or even not available at all. Also the problem in

emergency situations would be that the child has not been fasting before and a sufficient analgesia/anaesthesia is not possible to be administered [2,5].

The high analgetic, anxiolytic and sedative effects of nitrous oxide have been known worldwide for a very long time [5,6,7,8,9,10,11,12]. It is a good alternative to the other mentioned methods for pain management in the pediatric patient. It is absorbed and eliminated through the lungs and because metabolism does not take place in the body fasting is unnecessary. Side effects may occur, but are completely reversible at the end of the application [1,6,9,10,11,12].

The analgetic properties of nitrous oxide have been discovered by the dentist Horace Wells in 1844. Further uses were discovered in England in 1961 when a 50 % mixture of nitrous oxide and oxygen under the name ENTONOX® was used in the control of birth related pain with very good results. The 50 % mixture of nitrous oxide and oxygen

(EMONO: "equimolar mixture of oxygen and nitrous oxide"; MEOPA: "melange equimoleculaire oxygene/protoxyde d'azote") is being used for several years now under different commercial names in Europe: ENTONOX® in England, Poland, Cyprus, Spain, Czech Republic, Greece, Hungary, Slovak Republic, Romania, MEDIMIX® 50 in France and Switzerland, RELIVOPAN® in Belgium, Holland, Luxembourg, LIVOPAN® in Germany [6,7], Denmark, Finland, Island, Italy, Norway, Portugal, Sweden.

American dentists are using it very successfully for sedation [2].

The application of nitrous oxide in everyday practice is done by the pediatric surgeon or by a trained nurse. The presence of an anesthetist is not required [2]. While using nitrous oxide the requirements of occupational safety have to be taken into consideration, the gas should be applied only in a room with windows or a good ventilation system [6,1].

Since August 2008, the solid mixture of 50% nitrous oxide and 50% oxygen under the name of LIVOPAN® is approved in Germany for children and adults [6,7].

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The nitrous oxide-oxygen mixture is supplied in 2, 2,5, 5 or 10-liter pressure tanks with integrated pressure regulator and flow controller (demand-driven gas flow or constant). The inflow tube runs via a filter, the demand valve and a face mask to the patient [7]. When using a demand valve the awake and addressable patient controls through breathing the needs and even the effect of the gas. The application with a continuous flow is an alternative for younger patients. The compliance of the child can be enhanced by special masks and additional fragrances applied on the inside of the mask. The absorption and elimination of nitrous oxide takes place over the lungs, via the lungs, metabolism of the gas will not take place. The combination with other analgesics is possible. Side effects may occur, but they are completely reversible with the completion of the application. Minor side effects with an incidence of 5 % include nausea, vomiting, dizziness and paresthesia.

Major effects appear with a frequency of 0,33 % and are: decrease in oxygen saturation, bradycardia and loss of contact with the patient due to oversedation [7,12,13,14].

Material and method

Since August 2010 a solid mixture of 50% nitrous oxide and 50% oxygen under the name of LIVOPAN® is used in the Pediatric Surgery Clinic of the the University Mannheim for pain management. It is used for elective and

emergency small or medium procedures for inpatient or on an outpatient basis.

The procedure was discussed with the patients and their parents regarding the application of the gas and the expected effects, possible complications and alternatives for analgesia. Oral informed consent from the parents was obtained. The nitrous oxide was applied over a suitable face mask. Patients under 2 years of age were excluded from the study because of lack of compliance. Additional fragrances (strawberry, orange) were applied on the inside of the mask to enhance compliance of the patients. The mask was held by the patients themselves or the parent. The application of the gas occurred in a fully equipped ambulant operating room. A pulseoxymeter was applied on the finger of the patient before beginning of the procedure and a full survey of the patient by a trained nurse was undertaken. Before the actual procedure the mixture of 50% nitrous oxide and 50% oxygen was applied for at least 3 minutes. The application of nitrous oxide was stopped with the ending of the procedure, there was no need for further application of oxygen. The patients could be discharged shortly after the procedure. For the evaluation of treatment outcomes a documentation form for parents, caregivers and the doctors was created. Because of the nitrous oxide-induced retrograde amnesia an objective evaluation of outcome from the perspective of patients was not possible.

Emergency procedures	Elective procedures
32 wound closures	22 removal of Kirschner wires (fractures)
6 burns	2 removal of external fixateur
1 suprapubic catheter	13 cast wedge
2 reduction of paraphimosis	35 burns
2 incision of abscesses	17 placements of Foley urinary catheter for cistography
9 removals of foreign bodies	2 removal of preputial adhesions
24 closed repositions of minor displaced forearm fractures	1 removal of a sole wart
3 repositions of patella dislocation	
2 repositions of elbow dislocations	
3 repositions of finger dislocations	
13 reposition of finger fractures	
2 repositions of metacarpal fractures	
1 reposition of metatarsal fracture	
1 knee joint aspiration	
Total= 101 procedures	Total= 92 procedures

Table 1. Procedures performed

Results

In the period between the 01.10.2011 and 30.09.2012 a number of 162 children with the age between 2 and 16 years (mean age 7,5 years) in need of a acute or elective surgical intervention were treated with a solid mixture of 50% nitrous oxide and 50% oxygen and 193 procedures were performed (some children required multiple procedures) (Table 1). In- and outpatients over the age of two years with no significant other comorbidities wich needed elective or emergency small or medium procedures were included. The exclusion criteria included the age under 2 years, relevant comorbidities and the rejection of nitrous oxide by parents or the patient. The patient lot was composed of 91 male patients(56,18 %) and 71 female patients (43,82 %). Fasting before the procedure was not necessary.

The range of indications consisted in procedures for:

- Pediatric trauma (95/49,22 %)
- Burns(41/21,24 %)
- Wounds (32/16,58 %)
- Urologic procedures (22/11,39%)
- Septic surgery(2/1,03%)
- Dermatologic surgery (1/0,51%)

There were 101 (52,34%) emergency procedures and 92 (47,66%) elective procedures performed in the 162 children. The surplus of procedures is mainly attributed to the pediatric patients with burns, but also patients with multiple wounds, multiple Kirschner wire removal or multiple foreign bodies.

Monitoring of side effects under application of the solid mixture of 50% nitrous oxide and 50% oxygen was done by pulseoxymeter, as well as observation by trained nurse and physician. The presence of the parents as well as their support had also positive effects on the success of the procedure. There were no problems observed during monitoring of the patients. There were no side effects in 154 patients (95,06%), 6 patients accused mild nausea and 2 accused dizziness. These symptoms disappeared quickly after the application of nitrous oxide was stopped. Also there were light positive psychotropic effects (laughing, singing) in 32 patients (19,75%).

Very good analgetic and anxyolitic effects as well as retrograde amnesia were observed in 158 patients(97,53 %). In 4 patients the effects were not satisfactory, 2 of them presenting with forearm fractures, 1 with a elbow dislocation and 1 with a wound to the head. In 2 cases the procedure had to be interrupted, the patients were excluded from the study.

The satisfaction and acceptance of the solid mixture of 50% nitrous oxide and 50% oxygen in the ranks of patients, parents and physicians were very high. All parents would choose a application of solid mixture of 50% nitrous oxide and 50% oxygen under similar conditions again if there was the case, although only 6 parents or couples of parents have heard before that of this procedure.

Discussion

There is a great need for proper analgesia even for small procedures in children. The high analgetic, anxiolytic and sedative effects of nitrous oxide are well suited for this

purpose. It is a good alternative for oral, inhalative or intravenous analgesics. There is also a very low rate of side effects reported.

In emergency room conditions there are very often problems because of pain and fear of traumatized patients and the fact that they are not fastened or there is no capacity for a generale anesthesia for the moment.

Proper and age related analgesia and anesthesia are very important in the pediatric population. Burnweit et. al [12] observed the patients must not fasten before the procedure. They advised for the regular use of nitrous oxide in an emergency room in the USA and also Babl et al.[9] in Australia and Annequin et al. in France [8]. Nitrous oxide is applied in practice by special trained nurses or the pediatric surgeon himself [11,12,13,14,18,19,20,21].

Several authors reported that the use of a demand-valve in the administration of nitrous-oxide can reduce the complications rate [11,12,13,14,15,16,17,18,19,20,21]. The presence of a parent during the procedure can increase the compliance of the child[13].

Patients under 2 years of age were excluded from the study because of lack of compliance. By law there is a age related barrier of 4 years for pediatric patients in France[15]. Annequin et al. [8], Burnweit et al. [12] und Reinoso-Barbero et al. [19] reported better results in patients over 3 years of age. Burton et al. [13] reported about good results in a pediatric population with the age between 2 and 7 years. Gal et al.[15] described the emergency and elective application of nitrous oxide and also possible complications.

The therapeutic range of nitrous oxide is large but should not be overextended[9,13,22]. Gregory and Sullivan[16] reported of the quicker reposition of a forearm fracture when comparing nitrous oxide with regional anesthesia but Henrikus et al.[17] published a significantly high rate of therapy failures using nitrous oxide in the treatment of displaced forearm fractures.

Before the actual procedure the mixture of 50% nitrous oxide and 50% oxygen must be applied for at least 3 minutes[7,8,10,19]. The effects of nitrous oxide have a quick onset and also a quick ending. Intensive observation and application of 100 % oxygen like Bar-Meir et al. [10] and Ekbohm et al.[14] and suggested is not needed.

Gall et al.[15] reported minor and major side effects after 7511 applications of nitrous oxide in a pediatric population. They reported a incidence of 5 % minor side effects and 0,33% major side effects. We did not encounter any major side effects, minor side effects were seen in 4,93 % of patients (minor nausea, dizziness). These minor side effects disappeared with the termination of the application of nitrous oxide, concurring with the observations of Annequin et al. [8]. Annequin et al.[8] reported a rate of 12% dissatisfaction from the medical staff. The satisfaction and acceptance of the solid mixture of 50% nitrous oxide and 50% oxygen in the ranks of patients, parents and physicians in our lot was 100%. This is correlated maybe with a good preparation of the patient and parents before the procedure. Babl et al.[9] reported about the problem of self assessment in children with the age under 5 years, mainly because of the known issue of retrograde amnesia.

Burnweit et al.[12], Babl et al.[9,23] Reinoso-Barbero et al.[19] and other authors[13,14] have stated that nitrous oxide is a safe method for anesthesia and analgesia in pediatric patients. Babl et al.[23] recommended the application of nitrous oxide in patients with ages between 1 and 3 years as safe. However, it must be assumed that these were small interventions in otherwise healthy children. Other authors like Fröhleke et al.[24] and others[25,26,27,28,29] report about various side effects, some of them very serious[24], but especially in patients with associated diseases. The administration of nitrous oxide in critically ill children, children with a polypharmacy and systematically treated with folic acid antagonists may not be assessed as safe automatically [24,26,27]. Further studies are needed to clear this aspect.

Conclusion

If technique, indications, as well as side effects are well taken in consideration we can agree that nitrous oxide is a safe method for anesthesia and analgesia in pediatric patients. The major disadvantage is the fact that it is not a widespread and popular method, and as this fact only 6 couples of parents from our lot had heard about this method. The high percentage of acceptance of the method encourages us to recommend the usage of nitrous oxide in pediatric patients in Romania for elective as well as emergency small or medium surgical or orthopaedic procedures.

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