

Hand-disinfectant alcoholic vapors in incubators

C. Paccaud^a, D. Vernez^c, M. Berode^c, N. Charrière^c, A. Moessinger^{a,b} and B. Laubscher^{a,*}

^aDepartment of Pediatrics, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland

^bDivision of Neonatology, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland

^cInstitute of Work and Health (IST), Lausanne, Switzerland

Received 17 May 2010

Revised 30 September 2010

Accepted 5 October 2010

Abstract. *Objective:* To analyze the atmosphere inside incubators regarding alcoholic solvent such as isopropanol or ethanol which are commonly used in hand disinfecting solutions.

Design: Observational.

Setting: The third level neonatal unit of the Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland.

Patients: Nine neonates with median (range) gestational age of 29 4/7 (25 5/7–39 0/7) weeks and birth weight of 960 (550–3050) grams. All neonates were inside incubators.

Interventions: Alcoholic vapors inside incubators were directly and cumulatively measured by photoionisation and gas chromatography respectively after absorption on a charcoal sampling tube.

Results: Eleven studies (mean study time: 230 ± 19 minutes) were performed. Highly variable isopropanol/ethanol concentrations profiles were found inside incubators. Peak value for isopropanol was 1982 part per million and for ethanol was 906 part per million.

Conclusions: Incubators' inner atmosphere can be highly polluted by alcohol vapors. To reduce them staff should respect long evaporation time between hands disinfection and manipulations inside incubators. The use of an ethanol-based disinfecting solution, because of its short evaporation time, could be favored. As alcohol vapor toxicity for neonate remains largely unknown, further studies could be welcome.

Keywords: Neonate, isopropanol, ethanol, incubator

1. Introduction

Current best practices for hand hygiene in neonatal units include hand rubbing with an alcoholic solution whose main compounds are isopropanol and ethanol. Alcohol solutions are currently favored since they have a broad spectrum antimicrobial activity, develop their

full antiseptic activity within 15 to 30 seconds, have been shown to significantly improve compliance with hand hygiene and are well tolerated by health care workers' skin [1].

However, introduction of alcoholic vapors inside incubators after routine hand cleansing can occur if insufficient time for complete evaporation is not respected before introduction of the hand inside the incubator.

Current neonatal unit practices seek to optimize the physical environment of neonates by minimizing potentially noxious stimuli such as aggressive

*Corresponding author: Bernard Laubscher, Department of Pediatrics, Centre Hospitalier Universitaire Vaudois, 1011 Lausanne, Switzerland. Tel.: +41 32 913 44 16; Fax: +41 32 713 58 27; E-mail: bernard.laubscher@chuv.ch.

light, noise, and scents [2]. Evaporating alcohol from freshly disinfected hands can be very “smelly” and thus represent a potentially deleterious stimulus to neonates in incubators. Only one study analyzed the effect of an acute, brief, intense inhalation of an ethanol/isopropanol solution in preterm newborns: it showed cortical hemodynamic modifications whose consequences however are unknown [3]. There are no published environmental exposure limits for alcoholic solvents in neonates or even children. Furthermore, no data exist on the potential hazards of a chronic exposure to such vapors at a crucial stage of neurological development such as the neonatal period.

The aim of this preliminary study was to determine if ethanol or isopropanol vapors were found around neonates inside their incubators after routine hand cleansing by professional staff (nurses and doctors) and parents.

2. Material and method

The measurements were performed in the neonatal unit of the Centre Hospitalier Universitaire Vaudois (CHUV). Alcoholic solutions in use were Sterillium[®] (isopropanol based) and Sterillium Virugard[®] (ethanol based) (Bode, Beiersdorf AG, Münchenstein, Switzerland).

The study was based on a convenience sample. It was descriptive in nature and initiated as a quality improvement initiative.

The overall clinical workload determined when the primary author could perform bed site measurements. No systematic criteria were chosen to select which infant was to be studied. A study duration of approximately 4 hours was arbitrarily chosen as it was the longest period to fit easily in the first author’s work schedule.

Only Dräger IC 8000 incubators with an internal volume of 157 liters (Carbamed, Liebefeld, Bern, Switzerland) were used.

To determine the average concentration of both isopropanol and ethanol over each study period, cumulative measurement was performed on a charcoal absorption tube (Anasorb CSC 226-01, SKC inc., Eighty Four, PA, USA), air being sampled at a 100 ml/min flow with a pump (SKC pocket pump, Blanc-Labo, Tolochenaz, Switzerland) located outside the incubator. Charcoal sampling tubes were desorbed

with CS₂ and analyzed through gas chromatography (Capillary column CPSIL 8B 60Pm, Chrompack, Middelburg, Germany) with a detection limit of 1 microgram/tube (NIOSH/400 alcohols 1). Direct isopropanol and ethanol measurements were performed during the study period every 4th second using a pocket photoionisation detector (Toxi Rae[®], Rae Systems Inc., Sunnyvale, California, USA) with a detection limit of 3 ppm. All air sampling were realized close to the infant’s head where both probes were introduced at study time = 0.

Sterillium[®] producer recommends to “rub your dry hands with at least 3 ml alcoholic solutions for 30 seconds”. No specific recommendations were given to staff members or parents about the accurate amount of disinfecting solution to be used or the duration of hands rubbing. All interventions (defined as incubator doors opening with hand introduction inside it) were recorded concomitantly to the vapors measurements. Average time between each intervention as well as hand disinfecting ratio (proportion of interventions with disinfected hands) were thus computed.

To prevent any change in hand disinfection practices, staff and parents of a neonate inside a studied incubator were informed orally and with a short written protocol that “the air quality” inside the incubator was to be analyzed. No formal informed written parental consent was required as the study was considered as a quality control (personal communication, M. Burnier, head of the CHUV Ethics Commission).

3. Results

Nine neonates (median (range) gestational age/birth weight of 29 4/7 weeks (25 5/7–39 0/7), respectively 960 grams (550–3050)) were evaluated. Eleven studies were realized (mean study time 230 ± 19 minutes). Only nurses introduced their hands in the incubators during all recordings. The table shows average alcohol concentrations and peak values measured inside incubators. Wide range of exposure concentrations were seen within the same unit or with the same type of disinfecting solution. Peak concentrations could reach high values (case 4, 1982 ppm). The highest average concentration over 4 hours was 119 ppm (case 7). A typical exposure profile is shown in Fig. 1 (Table 1-case 7). Each peak represents alcohol introduction in the incubator, as solvent residues on nurse’s hands or

on disinfection swabs. Numbered arrows are given for some examples.

High exposure concentrations could be observed during short periods. In case 4, isopropanol concentration overshot 400 ppm during 5 minutes. In case 7, ethanol concentrations were greater than 200 ppm during two 20 minutes periods.

Studies 7 and 11 revealed the presence of both ethanol and isopropanol although only ethanol containing Sterillium Virugard[®] was in use at that time. The former was due to nurses hand disinfection. The latter to the infant's skin disinfection with an isopropanol solution.

Although all measurements were performed in the same department, the concentration profiles exhibited considerable discrepancies. While the neonatal special care unit (NSCU) profiles showed a score of well identifiable peaks followed by an exponential decrease, frequent increases and irregular decreases were observed on the neonatal intensive care unit (NICU) profiles.

The average time between two interventions in the NSCU and in the NICU were 21.9 min ($n=56$, $SD=23.1$), respectively 9.9 min ($n=63$, $SD=10.3$). Hands were disinfected prior to interventions in 70% of cases in the NSCU and in 38% of cases in the NICU.

4. Discussion

The purpose of this brief communication is to illustrate, using reliable measurement tools, the concentration of alcoholic vapors within an inhabited neonatal incubator over time. This work, for the first time, presents actual measurements of alcoholic vapor concentration inside incubators and should therefore be taken into consideration as illustrations of recognized potentially deleterious practices [2].

The concentration profiles observed inside incubators were highly variable. This variability was partly due to the lack of uniform patient selection criteria. The variability is also explained by the small incubator's volume as well as other factors: 1) the amount of solvent (and thus the maximal concentration) introduced at each manipulation is strongly influenced by the quantity of used hand disinfectant, the drying time before hands introduction and the manipulation duration. 2) The measuring site can determine the con-

centration kinetics since a direct contact or a very close proximity between the probe and the disinfected hands can influence the peak concentrations. 3) Air renewal conditions during and after each manipulation can affect the pollutant kinetics. For instance, rapid concentration decreases were observed during manipulations requiring the opening of several incubator's apertures or wide arms' movements inside the incubators. 4) The intervention frequency can affect the overall concentration profiles (peak concentration frequency) and can heavily weigh on average exposure concentrations. 5) Various alcohol containing products can influence solvent vapors levels in incubators: hand cleansing solution, disinfecting swabs or any alcoholic products to clean incubators inner walls.

Cohen et al. analyzed staff and visitors' interventions close to and within NICU incubators. Their interventions definition differed slightly from ours but, using their data, average time interval between their interventions within an incubator was computed to be 2.7 min (922 interventions over 41.6 hours), a much shorter interval than the 9.9 min. we found in our NICU. They also found that 38% of their interventions were preceded by correct hand hygiene practice, a similar ratio to what we observed in our NICU, using different hand hygiene practice though [4].

Intervention frequency can affect alcohol introduction inside incubators; the more interventions, the higher risks of exposure to alcohol. Neonates needing frequent manipulation (like Cohen et al.'s patients) could be exposed to even higher alcohol vapors than the NICU patients we studied.

Our study has a few limitations. First, it was based on a convenience sample and cannot thus be generalised to all neonatal patients or similar neonatal units. Second, although recorded prospectively, nurse hand disinfection before intervention inside an incubators could have gone unnoticed, especially during high workload periods with unstable sick neonates. We were effectively surprised and disappointed by the low 38% hand disinfection ratio in our NICU especially since we use the currently recommended best practices for hand hygiene which have been shown to significantly improve compliance with hand disinfection [1]. Third, little is known on the health hazards of neonatal exposure to isopropanol or ethanol vapors; literature reveals only a few acute intoxication case reports [5–9] but no data on their potential chronic/repetitive influences on the neonatal well being or developing olfaction,

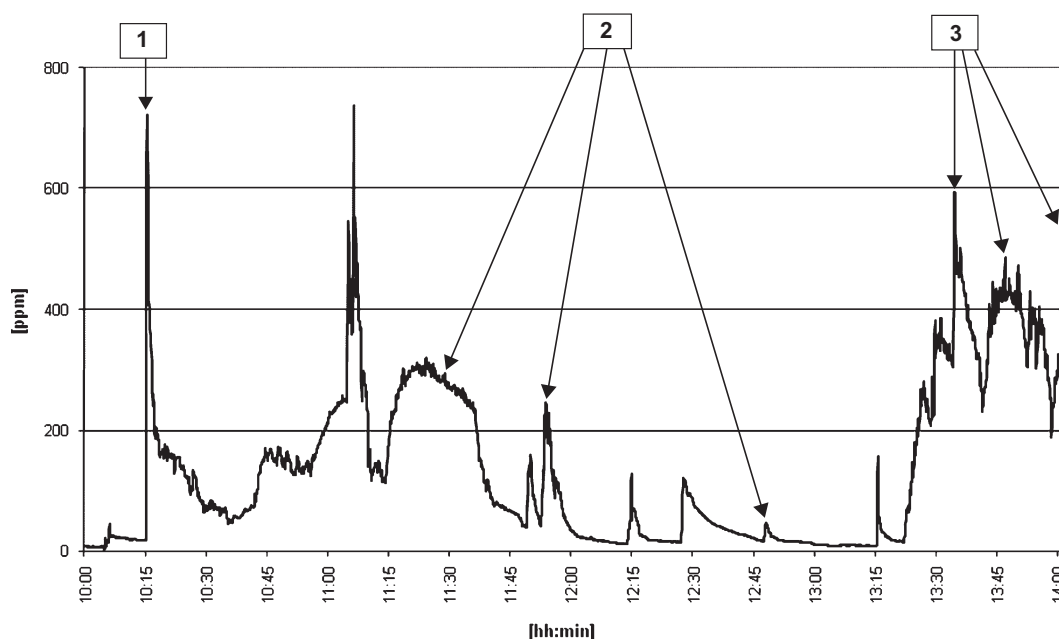


Fig. 1. Ethanol concentration over time in an incubator with a 1 day old neonate (gestational age 38 weeks 3/7, birth weight 3050 g) in the NICU. x-axis: time in minutes; y-axis: concentration in part per million (ppm). Arrow 1: ethanol rise in the incubator when introducing the solvent detector with dry but freshly disinfected hands. Arrows 2: multiple ethanol peaks during various procedures (umbilical artery catheter insertion, X-ray, blood sampling). Arrows 3: close to the study end, plateau elevation of ethanol at about 300 ppm for 50 minutes because of multiple manipulations with disinfected hands and introduction of disinfection swabs.

brain and other organs. Olfaction seems to be of high significance in the environment of both healthy and high-risk infants and the use of special odors could have long-term consequences on neural and behavioral development [10, 11]. Reference values for exposure to alcohol vapors exist only in the field of adult occupational health. Briefly, occupational exposure limits (OEL) have been defined for short (15 minutes

(OEL_S) and long (8-hours time-weighted average (OEL_L)) term exposures. In Switzerland, OEL_S and OEL_L for isopropyl alcohol and ethanol have been set at 400 ppm respectively 200 and 1000 ppm respectively 500 ppm [12]. It must be pointed out that OEL are established for healthy adults in chronic exposure conditions (workers). Therefore, they are not appropriate for neonates in incubators. We thus cannot evalu-

Table 1
Average solvent concentrations and peak values obtained inside incubators

	Time of analysis [min]	Disinfectant	Average concentration		Peak value [ppm]	Unit
			Isopropanol [ppm]	Ethanol [ppm]		
1	238	S	66.8	–	388	NICU
2	200	S	23.8	–	669	NSCU
3	246	S	13.8	–	545	NSCU
4	225	S	71.4	–	1982	NSCU
5	240	SV	1.3	26.3	273	NSCU
6	246	SV	<0.01	20.1	599	NSCU
7*	241	SV	119	>61**	906	NICU
8	193	SV	1.5	9.8	265	NICU
9	239	SV	0.13	15.5	n.r.	NSCU
10	245	SV	0.03	26.6	504	NSCU
11	218	SV	69.5	>33**	546	NICU

S = Sterillium®, SV = Sterillium Virugard®, NICU = neonatal intensive care unit, NSCU = neonatal special care unit, *see figure, **absorption tube saturated, n.r.: not reported.

ate our patients' risks on that basis although some were exposed to high concentrations for short periods (case 4).

We conclude that sick neonates in incubators can be exposed to alcohol vapors whose potential risks are largely unknown. Further study is encouraged. In the meantime, hand disinfection procedures at the incubators' side have to be analyzed: 1) sufficient time for complete alcohol evaporation has to be respected and 2) the use of an ethanol-based disinfecting solution, because of its shorter evaporation time, could be favored.

Financial disclosure

Authors declare no financial interest.

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