Variability in incubator humidity practices in the management of preterm infants

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Abstract

Aim: To determine current practice and opinion in relation to incubator humidity use in the management of preterm infants in neonatal intensive care units (NICU's) within the Australian and New Zealand Neonatal Network (ANZNN).

Methods: A survey was conducted in 26 NICU's in the ANZNN. A senior clinical nurse in each perinatal centre participated in a telephone survey that focused on local humidification practices and the clinicians' views and experiences of humidity use.

Results: All centres routinely used supplemental humidity in the management of preterm infants. The majority of centres (77%) had written protocols to guide practice. Eighty-eight per cent commenced humidity at a high level (relative humidity (RH) $\geq$ 80%). There was wide practice variation in the gestational age parameters determining humidification use (all gestational ages up to 37 weeks), duration of use (3 to 77 days), timing of initiation (admission to 72 hours after birth) and weaning practices. Perceived benefits of humidification included improved thermoregulation, skin integrity, and fluid and electrolyte balance and reduced transepidermal water loss (TEWL). Perceived risks included sepsis and hyperthermia.

Conclusions: Our study confirmed that incubator humidity is used routinely in the management of preterm infants in the ANZNN. Wide variation in humidification practices across NICU's reflects the paucity of research evidence. Perceived benefits and risks of humidity use were consistent with available literature. To optimise the care environment and provide an evidence base for practice further research is warranted.

Key words: infant, preterm, incubator humidity

Key Points:

Incubator humidity is used routinely in the management of preterm infants.

Optimal levels and duration of humidification have not been defined.

There is wide practice variation across NICU's in Australia and New Zealand.

Introduction

There is anecdotal evidence of widespread use of incubator humidity in the management of preterm infants within NICU's. Despite increasing use and reported short-term benefits of humidification, optimal levels and duration have not been defined and there is virtually no evidence of the effect of humidity on long-term health outcomes. Given the dearth of rigorous research, it is unclear what factors influence decisions determining humidity use in clinical practice. It is important therefore to examine existing humidification practices, explore the perceived benefits and risks of use and understand the challenges for clinicians posed by the lack of evidence.

Because the early studies of Blackfan and Yaglou[1] and Silverman and colleagues[2-4] reported improved outcomes for preterm infants in warm humidified environments, there has been interest in the use of incubator humidity. Based on physiological and observational work, the major argument for using humidity is to improve thermal stability, fluid and electrolyte balance and skin integrity by reducing evaporative heat and water loss from the skin[5-11]. Inability to optimise the care environment to achieve and maintain thermal stability and an adequate fluid balance is associated with significant morbidity especially in the most preterm infants[3, 12-17].

Transepidermal water and heat loss is highest in the most preterm infants immediately after birth and reduces with increasing postnatal and gestational age as the skin matures[8, 11, 18-23]. High incubator temperatures used in an attempt to reduce heat loss not only raise the infant's body temperature but also decrease humidity within the incubator[12]. Heat, in the presence of low-level humidity, increases skin permeability and surface evaporation, further increasing the potential for transepidermal heat and water loss. As the relationship between transepidermal

water loss (TEWL) and humidity is an inversely linear one, evaporative losses can be reduced with the provision of high-level humidity (relative humidity (RH) $\geq$80).[8,20,23]

However, evidence has yet to emerge in relation to the optimal level of humidity over time. One small study suggests that the provision of moderate levels of humidity (70%) beyond 14 days of age delays epidermal maturation thus increasing TEWL[24]. Similarly, optimal duration of humidification has not been defined reflecting the uncertainty in the literature as to when complete maturation of the extremely preterm skin occurs and whether it is necessary to humidify the environment until barrier function is fully developed.

Potential risks of humidification include sepsis[5, 25-30] and hyperthermia[5]. Both are associated with adverse neonatal outcomes[31-33]. While prolonged periods of high humidity may theoretically increase the risk of nosocomial infection, there is little mention of humidity as a causative factor in recent literature. The risks of hyperthermia are less well described than those of hypothermia in the preterm infant population.

A recent Cochrane review identified four clinical trials[2,4,24,34] involving 742 preterm infants that compared the effects of varying levels of humidification on neonatal health outcomes (L Sinclair and J Sinn, unpubl.data 2009). The review found no evidence that incubator humidity use reduces fluid requirements, weight loss or incidence of patent ductus arteriosus or increases the risk of intracranial haemorrhage, sepsis or mortality. Worthy of note, most of the included studies were of poor methodological quality and no studies compared varying durations of humidity or reported long-term outcomes in relation to humidity use. The review concluded that research that is more rigorous is required to optimise humidification practices and determine the benefits and risks of use.

Against this background, the major aim of our study was to determine current practice and examine existing protocols in relation to humidity use. The study also aimed to explore the

views of neonatal nurses on the benefits and risks of humidification, the factors influencing decisions in relation to humidity use and the challenges posed by the lack of robust research. Given the lack of evidence to guide practice we hypothesised there would be variation among NICU's in the ANZNN.

Materials and methods

Design

Perinatal centres in Australia and New Zealand that routinely provide care for preterm infants from birth were eligible for study inclusion. A structured telephone interview was conducted with a senior neonatal nurse in each centre.

Participants

Interviewees were senior members of the neonatal nursing team such as Clinical Nurse Consultant, Nurse Educator, Clinical Nurse Educator or equivalent Senior Nurse who had knowledge of current clinical practices.

Survey Instrument

In order to gain maximum participation a survey was developed that could be used in telephone interviews. The survey instrument was a questionnaire designed specifically for this study by the authors (see appendix 1). The questionnaire content covered the range of issues surrounding local humidification practices such as criteria for use, level and duration of humidity and the perceived benefits and risks.

Procedure

Approvals were obtained from the relevant human research ethics committees. Neonatal intensive care units were identified through the ANZNN. An initial telephone discussion

determined a senior nurse with knowledge of local humidification practices within each centre. Once identified, each nominated clinician received a personal email inviting them to participate in the survey. The email package included a letter of introduction, a participant information leaflet, a consent form and a copy of the interview questions. Follow-up emails and telephone calls maximised timely responses. The primary author who is also a Clinical Nurse Consultant within a NICU conducted telephone interviews between January 2006 and January 2007. Respondents were encouraged to discuss their own experiences of local guidelines and humidification practices within their clinical area following completion of the questionnaire. Duration of interviews varied from 20 to 50 minutes.

Analysis

Simple percentages were used to describe current practice in relation to incubator humidity use. Further qualitative information regarding individual participant's experiences and opinions of current practice provided additional data. Responses were grouped according to the major themes identified.

Results

Twenty-nine centres within the ANZNN provide intensive care for infants. Twenty-six perinatal centres that routinely provide care for preterm infants from birth were eligible for inclusion in the study. Three centres were excluded as they are Children's Hospitals and do not routinely provide care for this infant population. Following consent, all nominated neonatal nurses completed the telephone interview.

Table 1 describes the local humidification practices of the participating NICU's; all 26 centres humidified the microenvironment in the management of preterm infants. Supplemental humidity has been a standard of care for more than 5 years in 17 centres (65%). However, 23% of centres had no written protocol to guide practice in relation to humidity use. Although incubators

manufactured by Drager were most commonly used (73%), almost half of all centres used models designed and supplied by more than one manufacturer. One unit (4%) did not routinely use incubators but rather provided humidity via a plastic tunnel on an open care system under an overhead radiant warmer.

The humidification practices of participating NICU's are summarised in Table 2. Gestational age at birth was the most common criterion for humidity use. The median gestational age at commencement was 28 weeks. Where the criterion for use was birth weight, this was categorised as < 1000g or < 1500g. Seventy-seven per cent of centres commenced humidity within 6 hours of birth. The majority of centres set humidifiers to provide high-level humidity initially; this ranged from 80 to 100% depending on the type and capability of the incubator used. One unit (4%) did not measure the level of humidity provided.

Duration of use ranged from 3 to 77 days with a median of 28 days. Duration was dependent on attainment of a pre-specified postnatal age (23 centres (88%)) or weight gain (three centres (12%)). Of the 15 centres that provide humidity for more than 14 days, 6 centres (40%) usually provide humidity levels $\geq$70% beyond day 14 of life. Weaning from high-level humidity to a lower maintenance level appeared to be common practice with the majority of centres commencing weaning within 14 days. Weaning practices varied, with three centres (12%) using the weaning protocol of the Drager Computer Heat Balance Program.

There was consensus among respondents on the perceived benefits and risks of humidification as described in Table 3. By far the most common benefits reported were improved thermal stability and fluid balance but respondents stated that improved skin integrity and reduced TEWL and weight loss were also important. The respondents identified sepsis and hyperthermia as potential risks of humidity use. Complications of humidity use most commonly reported included the presence of rainout or condensation in 15 centres (58%) and the non-adherence of

monitoring equipment in 9 centres (35%). Rainout, prolonged periods of high-level humidity and long duration (any level of humidity) were factors that influenced sepsis concern.

Discussion

The results of our survey confirmed that incubator humidity use has become an accepted practice in the management of preterm infants within NICU's and, as hypothesised, revealed wide variation in humidification practices. Variations in practice were not surprising given the dearth of literature exploring optimal levels and duration of humidity, potential benefits and risks of use or its effect on long term health outcomes.

The majority of NICU's have used incubator humidity for more than 5 years. However, 6 of the 26 centres had no articulated policy or protocol to guide practice. Respondents described the anecdotal nature of existing protocols or guidelines and the variability in the extent to which clinicians adhered to them. Respondents reported that individual clinician preferences, experiences, beliefs and perceived benefits and risks of use as well as infant needs were observed to be significant contributors to many of the decisions made around humidification use and ultimately therefore to clinical practice.

There was wide practice variation across NICU's in relation to the criteria used to determine humidity use, the time taken to initiate therapy, the duration of use and weaning practices. By far the most important criterion reported to determine humidity use was gestational age. Although all centres humidified the environment in the management of extremely preterm infants, some provided humidity for infants of varying gestational ages up to 37 weeks gestation. Variation in the timing of initiation of humidification was also evident. ranged from immediately after birth to several hours or days after birth while variation in the duration of humidity use ranged from 3 to 77 days. While most centres (77%) commenced humidity within

6 h of birth (usually following stabilisation and arterial and venous catheterisation), humidity was not commenced in some centres until much later – sometimes commencing up to 72 h after

birth. Evidence suggests that TEWL is highest immediately after birth and that high-level humidity is required as soon as possible after birth to reduce large evaporative losses.[8,11,18–23]

Variation in the duration of humidity use ranged from 3 to 77 days. Duration of use was linked primarily to attainment of various pre-specified postnatal ages, often irrespective of gestational age at birth. Such differences in practice are not surprising given there are no studies that compare varying durations of humidification for infants of differing gestational ages.

Weaning was commenced anywhere between 3 and 28 days with no consensus among respondents on timing or what constituted an optimal low maintenance level of humidity. Three centres (12%) used the Dräger Computer Heat Balance Program.[35] The use of this programme, which calculates the required humidity level and weaning schedule based on gestational age, birthweight, and post-natal age, has previously been described in the literature.[36] Discussion with respondents revealed that the weaning process demanded active management of the environment and close monitoring of body temperature; simultaneously increasing the incubator temperature as the humidity level is reduced maintains thermal stability and prevents hypothermia.

This study found consensus across NICU's around the use of levels of humidity at the higher end of the range (RH $\geq$ 80%) and in the perceived benefits and risks of use. Humidity levels $\geq$80% were used in the management of extremely preterm infants in the first days or weeks after birth in the majority of centres. This is consistent with available evidence from physiological studies.5–7,10 Six centres provide humidity levels $\geq$70% beyond 14 days of life. Further research is required to determine whether such levels of humidity over time are associated with an increase in TEWL and a delay in epidermal barrier maturation as reported by Agren and

colleagues in 2006.[24] Serum sodium levels, skin integrity, fluid and electrolyte balance, and thermoregulatory state were reported to determine the level of humidity over time and the duration of humidity use in some centres.

Agreed perceived benefits of humidification included improved thermoregulation, fluid and electrolyte balance, skin integrity, and reduced TEWL and weight loss. Risks of use included the potential for sepsis and hyperthermia. Respondents reported that rainout was a frequent complication of high-level humidity. Rainout occurs when the canopy temperature is lower than the incubator air temperature. The resultant moist skin increased concern for infection risk. Other predictors for sepsis concern included the provision of high levels of humidity for prolonged periods and the provision of humidity (any level) for the longest durations. There was however, consensus among respondents that the perceived short-term benefits of humidity use outweighed potential risks.

Study Limitations

We acknowledge potential limitations of the study. We accept that the overall survey results reflect the experiences and opinions of one neonatal nurse in each NICU and we have no way of ascertaining the views of clinicians (both nursing and medical) who were not involved in our survey. We were however delighted with the 100% response rate and did achieve representation from nurses with diverse clinical backgrounds from all NICU's in the ANZNN. This leads us to believe that neonatal nurses consider the topic addressed in our survey to be important and relevant to everyday practice.

Conclusion

In summary, the results of our survey provide insight into humidification practices within NICU's in Australia and New Zealand. We have established that the provision of humidity is part of routine care in the management of preterm infants in all NICU's. As hypothesised, we

identified significant differences in practice both across and within institutions reflecting the lack of research to guide clinicians. Our findings demonstrate that current practices are for the most part consistent with the available literature and that variations reflect the existing gaps within. Our study illustrates that what is required is to establish new knowledge to guide clinicians and optimise the delivery of humidity in the management of preterm infants. Specifically, optimal levels and duration of humidification need to be defined and future trials need to be powered to detect clinically important differences in long-term neurodevelopmental and behavioural outcomes. The respondents in this survey voiced overwhelming support for such a study.

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