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EDITORIAL

Preventing hypothermia in preterm newborns – simple principles for a complicated task☆,☆☆

Prevenção de hipotermia em recém-nascidos prematuros – princípios simples para uma tarefa complicada

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Hypothermia is a major contributor to newborn mortality worldwide[1,2] and remains a common problem for very low birthweight (VLBW) infants, even in technologically advanced hospital settings.[3,4] The attributable risk of mortality from hypothermia is difficult to establish from the scant randomized trials on delivery room stabilization of VLBW newborns,[5] but the relationship between admission temperature and neonatal morbidities is U-shaped,[6] suggesting that both hypothermia and hyperthermia are undesirable. Consequently, the recommended goal for postnatal stabilization is to maintain a normothermic temperature between 36.5 and 37.5 °C.[7] In the past decade, several reports have documented success in decreasing hypothermia rates at neonatal intensive care unit (NICU) admission,[4,8] although high rates of hyperthermia were concomitantly induced in some studies.[9,10]

In this issue of *Jornal de Pediatria*, Caldas et al. report the results of a quality improvement (QI) intervention to decrease hypothermia in VLBW newborns admitted to a Brazilian NICU.[11] They successfully reduced the hypothermia rate from 37% at baseline to 14% in the post-intervention era, with a minimal increase in hyperthermia rates. The study design precludes evaluation of whether confounders such as decreased prophylactic surfactant administration contributed to the reported results. Without data to measure compliance with the thermoregulation process (*e.g.*, delivery room temperature, % plastic bags never opened), it is also unclear whether further improvement would be possible just by perfecting the current practices. Nevertheless, the authors' team attained clinically important improvements without resorting to additional physical assets and using apparently minimal human resources for QI.

This study illustrates several important points about minimizing neonatal hypothermia. First, Caldas' data, similarly to those from most of our NICUs, demonstrate that clinicians cannot assume that simply using technologies such as a radiant warmer will effectively prevent hypothermia in very preterm newborns. Indeed, in the baseline period, even when combining multiple evidence-based methods including a plastic bag and increased delivery room temperature, among others,[12] hypothermia was frequent. It was only with consistent application of the same methods, including attention to details such as keeping the bag closed during auscultation and other resuscitation interventions, that normothermia was reliably maintained.[11]

Second, hypothermia is not a condition that requires evidence from randomized clinical trials to establish which thermoregulatory interventions are effective. We know that

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a newborn's temperature *will* inevitably increase with any exothermic heat source; conversely, its decrease will be slowed by any interventions that diminish heat loss. However, to preserve thermal stability in practice, we must know how to reliably apply the basic principles of thermodynamics while resuscitating thermally labile newborns. Thermoregulation in the immediate postnatal period is largely passive, with heat exchange occurring along thermal gradients through well-known physical mechanisms, namely, evaporation, convection, conduction, and radiation. The rate and proportional contribution of each heat exchange mechanism varies with different patient and environmental conditions. Heat balance can theoretically be maintained despite large evaporative and convective losses, if sufficient exogenous heat is provided – generally from radiant and conductive sources. However, rapid rates of heat loss and gain can quickly generate temperature instability and accidental hyperthermia. Consequently, the easiest and safest way to maintain normothermia is to minimize heat losses, thereby minimizing the need for exothermic input. Because heat losses occur through multiple physical mechanisms, a ''bundle'' or combination of complementary methods is essential to counteract such losses, while providing exogenous heat as needed.[4,7]

A third lesson from this study is that neonatal care teams can attain substantial initial improvements in thermoregulation without substantial added material or personnel costs. The authors provided education to promote compliance with existing processes, and leveraged existing data, which were analyzed every six months, to provide feedback to the NICU staff. Ideally, a QI process involving rapid Plan-Do-Study-Act cycles would involve continuous data analysis and display current results at the front lines of care for greatest impact[13,14]; while this requires additional staff time, it also increases awareness, accelerates staff compliance, and creates multidisciplinary team spirit and support for the project.

Having recognized the extent of the admission hypothermia problem, standardized evidence-based practices, and successfully decreased hypothermia rates in their VLBW patients, Caldas et al. humbly conclude that there is still room for improvement in this measure in their NICU, and they set their next benchmark rate at 10%.[11] Which steps might they take to improve further? Would those steps be generalizable to other NICUs?

When admission hypothermia is frequent in a NICU, simple observation of delivery room stabilization will likely reveal obvious causes of heat loss by one or more of the four heat transfer mechanisms. Systematically countering as many of those causes as deemed feasible by a multidisciplinary QI team of delivery room and NICU staff (including physicians, nurses, and other support staff as needed) should rapidly produce improved results. Success in achieving the initial shared goals should be celebrated by the team to gain operational momentum. Once the proverbial low-hanging fruit is picked from the improvement tree, further gains may require the use of more formal QI methods, including data on local process (compliance) measures. If there is good compliance with all key care processes (*e.g.*, undisturbed plastic bag, delivery room temperature) and hypothermia remains too frequent, the care process must be redesigned, and it may be necessary to add other interventions to the thermoregulation bundle, such as thermal mattress.

To achieve the highest levels of thermoregulatory performance, the care team would benefit from engaging in collaborative QI with other centers. This provides not only external benchmarks for realistic improvement, but also a variety of potentially better practices, *i.e.*, ideas for which there is no formal evidence from randomized trials, but that are associated with superior results (*e.g.*, thermoregulation bundles). NICUs that engage in collaborative QI have achieved better thermoregulation outcomes than those whose QI efforts are exclusively local.[15] It should be noted that the components of successful thermoregulation bundles may vary across sites and time, and must be adapted to the local physical environment and resources. In our setting, for example, warm blankets were used to partially compensate for an administrative decision to remove chemical warming packs,[16] and additional methods were needed when competing institutional policies precluded raising the temperature of the cesarean section rooms.[4] Finally, eliminating rare residual cases of hypothermia requires additional local effort, including a debriefing after each event, using an informal root cause analysis framework, so that appropriate corrections can be made in the care processes.

Throughout the various stages of this improvement work, it is important to track balancing measures of hypothermia prevention, as possible indicators of adverse effects of the new processes. The most obvious balancing measure is hyperthermia, indicating overtreatment, whereas lower Apgar scores and other complications of resuscitation may signal interference of thermoregulation efforts with basic ventilation. Another essential consideration is the cost of interventions, which may vary considerably depending on whether the primary resources introduced include expensive new radiant warmers and disposable chemical mattresses, or inexpensive plastic wrap and warm blankets.

Admission hypothermia is becoming less prevalent, but it still occurs in about 40% of VLBW newborns in the Vermont Oxford Network,[17] which indicates that all NICUs have opportunities for improvement. As Caldas et al. demonstrate, improvement can be readily accomplished by carefully considering the basic principles of thermodynamics – minimizing heat loss and providing a combination of radiant and conductive heat. Ideally, tight thermal control of individual neonates by continuous monitoring with a skin probe (where available) during postnatal transition, coupled with continuous monitoring of QI data at the NICU level, should rapidly minimize the incidence of both hypothermia and hyperthermia. Monitoring at the individual and institutional levels will be important as the context of newborn resuscitation evolves; presently, increases in cold exposure can be anticipated during implementation of delayed cord clamping practices.

Hypothermia on admission is both an important problem and an opportunity for NICUs to achieve positive results with relative ease, by applying simple QI principles and tools. Tools, work habits, and multidisciplinary staff culture thus developed can then be used by clinical QI teams to address other quality and safety problems in their NICUs.

Conflicts of interest

The author declares no conflicts of interest.

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