Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/mjafi

Original article

Use of Plan-Do-Study-Act cycles to decrease incidence of neonatal hypothermia in the labor room

Lt Col Subhash Chandra Shaw^{a,*}, Col Amit Devgan^b,
Lt Col Sushila Anila^c, Maj Neha Anushree^d, Himadri Debnath^e

^a Assistant Professor, Department of Pediatrics, Armed Forces Medical College, Pune 411040, India

^b Senior Advisor & Head (Pediatrics), Command Hospital (Eastern Command), Kolkata 700027, India

^c Nursing Officer, Command Hospital (Eastern Command), Kolkata 700027, India

^d Graded Specialist (Pediatrics), Command Hospital (Eastern Command), Kolkata 700027, India

^e Resident (Pediatrics), Command Hospital (Eastern Command), Kolkata 700027, India

ARTICLE INFO

Article history:

Received 26 February 2017

Accepted 11 May 2017

Available online 19 June 2017

Keywords:

Neonatal hypothermia

Quality improvement

Plan-Do-Study-Act

Skin to skin contact

ABSTRACT

Background: Body temperature of a neonate continues to be under-documented, under-recognized, and under-managed, even though studies have shown that neonatal hypothermia increases mortality and morbidity. We aimed to reduce neonatal hypothermia (body temperature <36.5 °C) at 1 h following normal vaginal delivery in term and late preterm neonates in delivery room from 50% at baseline to less than 10% by 6 weeks.

Methods: We implemented a quality improvement (QI) initiative using the rapid-cycle Plan-Do-Study-Act approach (PDSA) improvement model and the project was conducted from 15 Jan 2017 to 25 Feb 2017. All singleton neonates with gestational ages above 34 completed weeks born by vaginal delivery were targeted. Exclusion criteria included neonates needing any form of resuscitation, those developing respiratory distress after birth needing any form of respiratory support or observation in NICU. We ran PDSA cycles (including pre-warmed cloths, skin to skin care with mother, early breast feeding, delaying weight check by 1 h and checklist of planned steps), every week, after taking the baseline data in the first week.

Results: A total of 46 neonates were studied. After 4 PDSA cycles, incidence of neonatal hypothermia at 1 h of birth dropped to zero from 50% at baseline and we were able to sustain 100% normal temperature (36.5–37.5 °C) since then.

Conclusion: This QI project has significantly reduced the incidence of hypothermia in term and late preterm neonates born by vaginal delivery in our institute.

© 2017 Published by Elsevier B.V. on behalf of Director General, Armed Forces Medical Services.

* Corresponding author:

E-mail address: drscshaw@rediffmail.com (S.C. Shaw).

<http://dx.doi.org/10.1016/j.mjafi.2017.05.005>

0377-1237/© 2017 Published by Elsevier B.V. on behalf of Director General, Armed Forces Medical Services.

Introduction

Thermal control is an essential aspect of neonatal care and is closely associated with increased morbidity and mortality. The 10 steps of warm chain recommended by WHO for essential new born care are keeping the delivery room warm, immediate drying, skin-to-skin contact, early initiation of breastfeeding, delayed of bathing, appropriate clothing, warm transport (in case necessary), keeping mother and baby together, warm resuscitation, and increased awareness and recognition of risk of hypothermia are considered standard of care to prevent neonatal hypothermia in the delivery room.¹ According to the World Health Organization (WHO), body temperature between 36.5 °C and 37.5 °C is considered to be in normal range, temperature between 36 °C and 36.5 °C is cold stress, temperature between 36 °C and 32 °C is moderate hypothermia, and temperature below 32 °C is severe hypothermia. The incidence of hypothermia, even in facility based estimates has been as high as 83% at 6 min after birth at Uganda if the WHO definition of hypothermia (<36.5 °C) is applied,² to 85% at 2 h after birth at Nepal³ if the cutoff of neonatal hypothermia is taken as <36 °C. It continues to be under-documented, under-recognized, and under-managed, even though studies have shown that neonatal mortality increases by 28% for each 1 °C decrease in admission temperature below 36 °C.⁴ We identified baseline neonatal hypothermia rates (body temperature <36.5 °C) at 1 h after birth, in late preterm and term neonates, born by normal delivery to be about 50%. Hence, we initiated a quality improvement (QI) project to prevent neonatal hypothermia following delivery by standardization of labor room care. Our target temperature was an axillary skin temperature between 36.5 °C and 37.5 °C and we achieved this goal by implementing a QI initiative using the rapid-cycle Plan-Do-Study-Act approach (PDSA) improvement model.

Methods

Our institute is a tertiary care teaching service hospital of eastern India that has a delivery rate of about 800 neonates per year. We wanted to work on various neonatal issues as QI initiative for neonates. When we filled up the prioritization matrix, as per our experience in our facility, we found neonatal hypothermia at 1 h following delivery to be very important to the patient (neonatal) outcomes, affordable in terms of time and resources, easy to measure, and was under control of team members. We obtained institutional ethics committee approval for data collection and publication of the results of our QI effort. We formed a team comprising of the neonatologist, the in-charge nurses of the delivery room and maternity ward, and two residents working in the postnatal ward. The project was conducted from 15 Jan 2017 to 25 Feb 2017. The average ambient temperature remained between 19 °C and 23 °C respectively, in the months of January and February, in this part of the country. The ambient temperature was recorded by the mercury thermometer (G.H. Zeal, London, England) having minimum and maximum values in a day. All singleton neonates with gestational ages above 34 completed weeks born by vaginal delivery were targeted. Exclusion criteria

included neonates needing any form of resuscitation and those developing respiratory distress after birth needing any form of respiratory support or observation in NICU. Axillary temperature was taken by a digital thermometer (Olex, Japan) at exactly 1 h after birth and was kept in axilla till the beep was heard. The study methodology followed was the rapid-cycle Plan-Do-Study-Act approach (PDSA) improvement model. The plan was to run PDSA cycles every week after taking the baseline data in the first week and study the results at the end of every week and act accordingly.

We gathered baseline data for about a week in initial week of the study (first 10 neonates) and identified that the rate of hypothermia was 50% in late preterm and term neonates following normal vaginal delivery. The aim of the study was to reduce neonatal hypothermia (body temperature <36.5 °C) at 1 h following normal vaginal delivery in term and late preterm neonates in delivery room from 50% at baseline to less than 10% by 6 weeks through implementation of improvement interventions.

We presented the results of the baseline data in the team meeting and tried to find out the possible reasons of high rate of neonatal hypothermia. Root cause analysis (fish bone analysis) of the cases of hypothermia identified the following issues (Fig. 1):

1. Place: Ambient air temperature in delivery room was often less than 25 °C, due to ongoing winter or because the fan or air conditioning was on.
2. People: There was knowledge gap among the staff regarding neutral thermal environment and possibility of hypothermia in neonates. Staffs were also unaware about the need to check temperature of neonates or the recommendations of skin-to-skin contact with mothers.
3. Policy: No existing standard operating procedure (SOP) addressing delivery room care to maintain normal temperature in neonates.
4. Procedure: Babies were taken to a pre-warmed radiant warmer for placing after delivery and wiping was done with a pre-warmed towel and the wet towels were changed. Skin-to-skin contact was not being practiced. Neonates were clothed late or just being wrapped in a towel. The weight measurement and taking footprints, administering injections of vitamin K and Hep B took precedence over keeping babies warm. Breast feeding was started late, often after suturing of episiotomy wound or shifting of mother from the labor table to another bed. All this while, the baby used to remain wrapped in OT towel and placed on the side of mother.

PDSA cycle 1:

In the first cycle, we received every neonate at birth on warm pre-warmed towel and placed on mother's abdomen. Babies were dried on abdomen, the wet linens were changed, and the neonate was placed prone on the abdomen and chest of mother. After ensuring skin-to-skin contact, neonate's back was covered with another pre-warmed towel and breast feeding was initiated. It was ensured that the fan or AC was put off at least 15 min before any delivery. We found the hypothermia rate at 1 h to have further deteriorated with hypothermia (temperature < 36.5 °C) rates of about 86%

Fig. 1 – Fish bone analysis of baseline neonatal hypothermia.

(though temperature of all babies remained above 36 °C). We learned in this cycle that drying the baby thoroughly was even more difficult on mother's abdomen as compared to that on a warmer and thus wiping was largely incomplete. The babies did not have hats on their heads and no covers except a towel each, hence maintaining normal temperature was even more difficult. The nurses were also uncovering the baby for administering injections of Hep B and Vitamin K. Babies were also being taken for checking weight in between, thereby exposing the baby to cold weighing machine.

PDSA cycle 2:

In the second cycle, we received each baby on a pre-warmed radiant warmer, dried by a pre-warmed towel, wet linen was changed, and then the baby was clothed with nappy, front open vest, hat, and socks. After that, the baby was put on skin-to-skin contact on mother's abdomen with front of vest open. The baby was also covered on back in addition by a pre-warmed towel and started on breast feeds soon after birth. It was ensured that the fan or AC was put off at least 15 min before any delivery. Checking of weight, taking footprints, and administering injections were planned at the end of 1 h. We found the hypothermia rates at 1 h dropping to 30%. Still, we were not close to our target and the probable reason thought was that cloths of the babies were not pre-warmed and incomplete adherence to process measures.

PDSA cycle 3:

In the third cycle, we made another change. We pre-warmed clothes under the warmer and after thorough drying, babies were clothed by warm clothes with front side of vest open. Rest of the steps were same as PDSA cycle 2. Our hypothermia rate went down to 17%, but yet we did not achieve our target. We realized that in spite of continuous engagement with the staffs and repeated discussions, the process measure (compliance of all the steps) was still poor. So the implementation was still not up to the mark because of frequent changing of obstetric and neonatal team members. Often babies were not on mother's chest and abdomen for full

1 h and in between the babies were being taken out for weight measurement, taking footprints and giving injections.

PDSA cycle 4:

Fifth week onwards, we started our 4th PDSA cycle and we made a checklist (Table 1) with explicit steps, point wise for better understanding and compliance and handed over to all working in labor room. We also made a SOP and placed it prominently in labor room, at washbasin areas and on the tables of the duty rooms for strict adherence. We also included enthusiastic nursing cadets in the team who used to assist in child birth and remind the labor room team in case of any breach in protocol. The steps of PDSA 3 remained same but the adherence to protocol improved substantially. Our hypothermia rate dropped to zero and we were able to sustain 100% normal temperature since then. The cumulative results were regularly updated and run charts were disseminated throughout the department.

Table 1 – First hour checklist.

Baby particulars
Warmer on at least 15 min prior to expected delivery
Warm baby clothes, including vest, cap, socks and 2 sets of OT towels on warmer before delivery
Receive baby on a pre-warmed towel and cut umbilical cord after one full min
Place baby on warmer, dry thoroughly and remove wet towel
Cloth the baby with previously warmed cloths including front open vest, socks, cap
Place baby on mother's abdomen and chest prone with front side of vest open
Place another pre-warmed towel over the back of baby
Keep baby on mother's chest and abdomen for full 1 h and help in breast feeding
Take axillary temperature at end of full 1 h
Postpone rest all activities like taking weight, giving injections, taking foot prints for one full hour

Results

Baseline characteristics of all included neonates are depicted in Table 2. We studied 10, 7, 10, 7, and 12 neonates in baseline, PDSA 1, 2, 3, and 4 respectively. The outcome measures in percentage of attaining normal body temperature after each

PDSA cycle have been depicted in Fig. 2. The run chart depicting temperature of individual neonates is depicted in Fig. 3. As compared to baseline, the reduction in incidence of hypothermia after PDSA 4 was significant ($p = 0.006$). The process measures, i.e. adherence to all the steps planned for each PDSA could be achieved 100% only by PDSA 4. The balancing measures we checked were any discomfort felt by

Table 2 – Baseline characteristics of enrolled neonates (n = 46).

Enrolment no	Period of gestation (weeks)	Birth weight (kg)	Birth order	Temperature (°C)
<i>Baseline</i>				
1	37	2.03	Primigravida	36.2
2	38	3.68	Primigravida	36.8
3	37	2.06	G2A1	36.8
4	40	3.09	Primigravida	36.6
5	37	2.91	G5P2A2	36.2
6	39	2.86	Primigravida	36.2
7	37	3.40	Primigravida	36.6
8	38	2.91	G2P1	37.7
9	38	3.48	G4P1A2	35.8
10	37	2.88	Primigravida	36
<i>Plan-Do-Study-Act cycle 1</i>				
11	40	3.94	Primigravida	36.5
12	38	2.94	Primigravida	36.3
13	39	3.38	G2P1	36.2
14	37	3.02	Primigravida	36.4
15	39	3.20	Primigravida	36.1
16	37	3.17	Primigravida	36
17	39	3.58	G3P1A1	36.2
<i>Plan-Do-Study-Act cycle 2</i>				
18	40	3.03	Primigravida	37
19	39	3.34	Primigravida	37
20	39	3.21	G2A1	36.3
21	38	2.94	G3P1A1	36.7
22	34	2.41	G3P1A1	36.7
23	36	2.21	Primigravida	35.9
24	37	2.71	Primigravida	36.1
25	37	3.29	G3P1A1	37.1
26	37	2.90	Primigravida	36.8
27	39	3.28	G2P1	37
<i>Plan-Do-Study-Act cycle 3</i>				
28	40	2.61	G2A1	36.4
29	38	2.96	G2P1	36.8
30	39	3.59	G2P1	36.8
31	37	2.29	G2P1	36.8
32	38	2.51	G2P1	36.7
33	37	2.70	G2P1	36.9
34	39	2.31	G2A1	36.1
<i>Plan-Do-Study-Act cycle 4</i>				
35	39	3.0	Primigravida	37
36	37	2.60	G3P1A1	36.7
37	39	3.52	Primigravida	36.8
38	39	2.81	Primigravida	36.7
39	37	2.56	Primigravida	36.7
40	39	2.66	Primigravida	37.2
41	40	2.72	G2P1	36.7
42	37	2.76	Primigravida	36.7
43	39	3.32	Primigravida	36.7
44	38	3.26	G2P1	37
45	38	3.19	Primigravida	37.1
46	37	3.34	Primigravida	36.7

Fig. 2 – Change in percentage of neonates with normal temperature in successive PDSA cycles.

mother and neonatal hyperthermia (axillary skin temperature beyond 37.5 °C) at 1 h. So far we have not come across any case of maternal discomfort or any case of hyperthermia at 1 h.

Discussion

Soon after birth, initial heat loss can be quite large, even by 2–4 °C in first 10–20 min.⁵ Heat loss occurs in a neonate by four basic mechanisms. These mechanisms are evaporative heat loss of amniotic fluid, conduction (direct transfer of heat from the neonate to contact surface), heat loss by convection (to cooler surrounding air), and radiation (indirect transfer of heat to nearby objects having lower temperature).^{1,6} There are certain risk factors which further make a neonate prone to hypothermia, and these are environmental, physiological, socioeconomic, and behavioral. Incidence of neonatal hypothermia is known to vary between winter and summer months.⁷ Physiological and anatomical factors like greater body surface area per weight in neonates is higher as

compared to adults and more so in preterm babies. Low birth weight neonates and those with intrauterine growth restriction are more prone to have low body temperature.⁸ Among socioeconomic factors, low socioeconomic status and young and inexperienced mother are important factors.⁹ However, the behavioral factors are the specific new born care practices which substantially contributes to the loss of heat. Child birth in a sub-optimally warmed room, placing the baby on a cool surface while awaiting delivery of placenta, not drying or inadequate drying of baby at birth, inadequately wrapping baby after drying, not pre-warming of wrapping cloths, immediate bathing of baby, and not breast feeding early enough are all modifiable practices that increases risk of heat loss.¹

The recommendations by WHO for thermal care of neonates at birth are primarily based on behavioral practices.¹ A study in Uganda showed that bathing of neonates at 60 min of birth increased hypothermia even after using warm water and in spite of skin to skin contact.¹⁰ On the other hand, proper wiping and drying were found to prevent significant drops in

Fig. 3 – Run chart of temperature of individual neonates.

temperature in the first 2 h after birth.¹¹ Woolen head caps are recommended preferably for all babies as suggested by a study by Lang et al.¹² Skin-to-skin care has been shown to be at least as effective as incubator for management of hypothermia in low-risk neonates.¹³ Early initiation of breast feeding have proven to have prevented hypothermia in Nepal as per a large study by Mullany et al.¹⁴ Breast feeding helps by both close contact with the mother as well as by providing calories from fat.

In spite of all the established facts mentioned above, the studies have often shown that there are various cultural and behavioral barriers that interfere with implementing simple steps to prevent hypothermia.¹⁵ In a cross-sectional study from rural Nepal, it was seen that only 64% of neonates were wrapped within 30 min of birth and more than 90% neonates were given a bath by 1 h.¹⁶ In a qualitative research study from Ghana, though respondents knew that keeping the neonate warm was essential for health, but 71% of the neonates born at home had delayed drying, 79% had delayed wrapping, 93% had early bathing, and only 10% were placed skin-to-skin with the mother.¹⁷

In our project, we could achieve 100% normal temperature in neonates by drying well, covering body by pre-warmed cloths, doing skin-to-skin care on mother's abdomen and chest, starting breast feeds early and by making it mandatory to do all other activities including weight check, administering injections, etc. after 1 h. Though it would have been ideal to increase the ambient room temperature as well, by additional room heaters, we did not need this step. We strongly recommend to keep labor room ambient temperature to be more than 25 °C, but practically often we face sub-optimal environmental temperature in spite of our best efforts.

The lessons learnt from this QI project included the importance of reiterating information and team effort, use of motivated champions, regular feedback for correcting previous PDSA cycles, and utility of checklists. Regular feedback was also important to highlight success. Simplification of what to do in easy steps and including volunteers in the team made the difference. The barrier to improvement was to bring change in established practices/attitudes. There are important limitations to our study as well. This QI project using rapid PDSA cycles included all singleton neonates above 34 weeks of gestational age, but excluded those born by cesarean sections in which feasibility of doing skin to skin was difficult to implement. In our facility, as there is an established practice of neonatal transport by transport incubator from operation theater, we could not have studied in them the same way. The need and importance of maintaining normal temperature is more in low birth weight (LBW) neonates, but we did not have enough sample size of LBW neonates for the study in such a rapid cycle short time span.

Conclusion

This QI project has significantly reduced the incidence of hypothermia in term and late preterm neonates born by vaginal delivery in our institute. This project also facilitated understanding of PDSA methodology and value of quality improvement in the delivery room of our facility. Through this project, we also ensured 100% breast feeding as soon as

possible after birth, which was another gain from the project. We recommend disseminating the results to other facilities and make continual improvement by analyzing further change.

Conflicts of interest

The authors have none to declare.

Acknowledgments

We sincerely acknowledge the invaluable contributions of Col A.K. Srivastava, senior adviser (Obst and Gynae), Command Hospital (EC) for supporting this QI project. We also acknowledge contributions of Dr. Subhasis Sardar and Dr. Sayantan Saha, residents in Dept of Paediatrics and Maj Aswathi Raghavan, nursing officer of Command Hospital (EC) for participating in this project.

REFERENCES

1. *Thermal Protection of the Newborn: A Practical Guide [Monograph on the Internet]*. Geneva, Switzerland: Maternal and Newborn Health/Safe Motherhood Unit, World Health Organization; 1997:64. Available from: http://whqlibdoc.who.int/hq/1997/WHO_RHT_MSM_97.2.pdf.
2. Byaruhanga R, Bergstrom A, Okong P. Neonatal hypothermia in Uganda: prevalence and risk factors. *J Trop Pediatr*. 2005;51:212–215.
3. Johanson RB, Spencer SA, Rolfe P, Jones P, Malla DS. Effect of post-delivery care on neonatal body temperature. *Acta Paediatr*. 1992;81:859–863.
4. Laptok AR, Salhab W, Bhaskar B. Neonatal Research Network. Admission temperature of low birth weight infants: predictors and associated morbidities. *Pediatrics*. 2007;119(March (3)):e.643–e.649. <http://dx.doi.org/10.1542/peds.2006-0943>.
5. Kumar V, Shearer JC, Kumar A, Darmstadt GL. Neonatal hypothermia in low resource settings: a review. *J Perinatol*. 2009;29:401–412.
6. Polin RA, Fox WW, Abman SH. *Fetal and Neonatal Physiology*. 3rd ed. Philadelphia: Saunders; 2004.
7. Bang AT, Reddy HM, Baitule SB, Deshmukh MD, Bang RA. The incidence of morbidities in a cohort of neonates in rural Gadchiroli, India: seasonal and temporal variation and a hypothesis about prevention. *J Perinatol*. 2005;25(suppl 1):S18–S28.
8. Mance MJ. Keeping infants warm: challenges of hypothermia. *Adv Neonatal Care*. 2008;8:6–12.
9. Zabelle J, Dagan R, Neumann L, Sofer S. Risk factors for infantile hypothermia in early neonatal life. *Pediatr Emerg Care*. 1990;6:96–98.
10. Bergstrom A, Byaruhanga R, Okong P. The impact of newborn bathing on the prevalence of neonatal hypothermia in Uganda: a randomized, controlled trial. *Acta Paediatr*. 2005;94:1462–1467.
11. Christensson K, Ransjo-Arvidson AB, Kakoma C, et al. Midwifery care routines and prevention of heat loss in the newborn: a study in Zambia. *J Trop Pediatr*. 1988;34(5):208–212.

12. Lang N, Bromiker R, Arad I. The effect of wool vs cotton head covering and length of stay with the mother following delivery on infant temperature. *Int J Nurs Stud.* 2004;41(8):843-846.
13. Christensson K, Bhat GJ, Amadi BC, Eriksson B, Hojer B. Randomised study of skin-to-skin versus incubator care for rewarming low-risk hypothermic neonates. *Lancet.* 1998;352(9134):1115.
14. Mullany LC, Katz J, Khatri SK, LeClerq SC, Darmstadt GL, Tielsch JM. Neonatal hypothermia and associated risk factors among newborns of southern Nepal. *BMC Med.* 2010;8:43.
15. Lunze K, Bloom DE, Jamison DT, Hamer DH. The global burden of neonatal hypothermia: systematic review of a major challenge for newborn survival. *BMC Med.* 2013;11:24.
16. Osrin D, Tumbahangphe KM, Shrestha D, et al. Cross sectional, community based study of care of newborn infants in Nepal. *BMJ.* 2002;325:1063.
17. Hill Z, Tawiah-Agyemang C, Manu A, Okyere E, Kirkwood BR. Keeping newborns warm: beliefs, practices and potential for behaviour change in rural Ghana. *Trop Med Int Health.* 2010;15:1118-1124.

AWARDS FOR BEST PUBLISHED SCIENTIFIC PAPERS

1. The following awards will be presented during the 67th Armed Forces Medical Conference-2019 to be held at AFMC Pune in the month of Feb 2019 vide O/o DGAFMS letter no. 15969/67th/2019/DGAFMS/DG-3B dt 06 Apr 2018.
 - (a) **Chief of the Army Staff Award** for best published article in the field of **Pathology, Microbiology, Hematology & Biochemistry.**
 - (b) **Chief of Naval Staff Award** for best published article in the field of **Medicine & allied specialities including Marine Medicine & Aviation Medicine.**
 - (c) **Chief of Air Staff Award** for published article in the field of **Surgery & allied specialities including Dental Surgery.**
 - (d) **DGAFMS & Sr Col Comdt Award** for best published article in the field of **Community Medicine including Epidemiology, Biostatistics, Health & Hospital Administration.**
 - (e) **Late Lt Gen RS Hoon Award** for best published article in the field of **Cardiac Sciences including Cardiology, Cardiothoracic Surgery or a research related to Cardiac Sciences from Medicine/ Surgery and allied specialities.**
2. Validity of paper: Article should have been published/accepted in the previous year i.e. Award being presented in Feb 2019 would be for the year 2018 and so the article should have been published/accepted in between 01 Jan 2017 and last date of submission (i.e. 31 Aug 2018). **The paper should have been approved by the office of DGAFMS before publication.**
3. The articles/papers should reach O/o DGAFMS through proper channel latest by 31 Aug 2018 accompanied by the following enclosures:
 - (a) One re-print copy of the published article / article accepted for publication.
 - (b) Name of the journal along with Thomson Reuters impact factor in which the article has been published.
 - (c) No. of citations with proof thereof.
 - (d) DGAFMS approval obtained for the article to be published in a journal other than MJAFI.
 - (e) Certificate of plagiarism attached as per Appx to O/o DGAFMS letter no. 15969/67th/2019/DGAFMS/DG-3B dt 06 Apr 2018.
 - (f) Soft copy of the article word format should be email to dirmr.afms@nic.in & jtdirmr.afms@nic.in