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Chapter

Golden Hours: An Approach to Postnatal Stabilization and Improving Outcomes

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Abstract

The "Golden Hour" model of care originated in adult trauma medicine. Recently, this concept has been applied to premature neonates and the care they receive immediately after birth. This is not limited to the first hour of life, however, as this approach encompasses the first hours and days after birth. While no universal description defines the Golden Hour model, critical domains include initial delivery room management, thermoregulation, ventilation and oxygenation, glycemic control and prevention of infection. Strong evidence favors standardization of care to improve short- and long-term outcomes. This approach to care for the most at-risk premature infant is typically institution-specific; thus, team-building and quality improvement are critical to the care of these vulnerable patients.

Keywords: Golden Hour, prematurity, preterm, neonate, extremely low birth weight infant, resuscitation, quality improvement

1. History and introduction

The "Golden Hour" concept derives from the adult trauma literature, and generally describes the period after a traumatic injury during which prompt medical attention is needed to prevent death. The term was first introduced by a military surgeon, R. Adams Cowley. Cowley's research was directed primarily at the management of post-traumatic shock. According to Cowley, shock is a "momentary pause" in the pathway leading to death, and the "golden hour" is that period in which life-saving interventions can be initiated to prevent death or extreme morbidity. Cowley's research was instrumental in the study of shock and trauma in the United States, and his contribution has influenced the care of high-risk newborns as well.

For over a decade, neonatologists have been applying this concept to the care of high-risk newborns in the neonatal intensive care unit (NICU) [1]. However, the Golden Hour conveys a slightly different meaning in the NICU. In the NICU, the term generally refers to the first few hours immediately after birth. High-quality, timely, and efficient care, initiated within the Golden Hour window, can mitigate at least some of the risks associated with high-risk newborn care. Golden Hour protocols generally include standards and guidelines based on available evidence that can decrease morbidity and mortality. Here we discuss the Golden Hour concept for care of preterm infants, especially those born less than 28 weeks post-menstrual age

(PMA). Extremely preterm newborns are highly vulnerable to complications in the early postnatal period, and adherence to best-evidence standards or guidelines can improve both survival and neurodevelopmental outcomes [2].

The aim of a Golden Hour protocol in the NICU is to apply evidence to clinical practice as safely and efficiently as possible. While the term "Golden Hour" implies the first 60 minutes after birth, the first several hours to days are critical as well [3]. The care of each infant must be individualized, but the Golden Hour concept emphasizes preparedness and adherence to guidelines with the aim of improving the quality of care. One author described the Golden Hour as a "philosophical approach" that reinforces communications, evidence-based protocols and procedures, and standardizes as many elements as possible with the aim of improving care and outcomes [2].

The outcomes improved by Golden Hour care are those most important to parents: survival, chronic lung disease, hearing and vision, and long-term neurodevelopment [3]. Early postnatal metrics are essential in the development of Golden Hour protocols, and there is strong evidence that improving specific components of care improves long-term outcomes as well. Among the most important of these are delivery-room practices such as teamwork, leadership, and communication, the use of oxygen and positive pressure ventilation, hemodynamic management, maintenance of a thermo-neutral environment, glycemic control, and identification and management of infectious risk factors.

While there are no randomized controlled trials evaluating any one comprehensive Golden Hour protocol, there is ample support for the use of evidence-based standards in several clinical domains unique to the early postnatal period. One report of a standardized protocol demonstrated a 67% reduction in mortality over the course of 10 years (1978–1988) [4]. Standardization may be just as important as the specific clinical practice strategy being implemented. This is important because resuscitation teams frequently deviate from resuscitation algorithms [5]. Finer et al. identified several deviations from resuscitation guidelines, including deep oropharyngeal suctioning, excessive stimulation, poor communication of heart rate, and failure to troubleshoot during bag–mask ventilation [6]. Units in the United Kingdom reported marked variations in practice between units with different designations, suggesting that either the level of care or the experience of clinical staff were factors in the quality of care delivered [7]. Similarly, a national survey in the United Kingdom demonstrated marked variations in delivery room practice; and differences persisted 1 year after publication of revised consensus guidelines [8].

2. Burden and global impact

Adaptation to extra-uterine life occurs during the early postnatal period and is a very high-risk period for premature infants, especially those born extremely preterm. Clinical domains of special interest during the Golden Hours include: delayed clamping of the umbilical cord, appropriate use of supplemental oxygen, non-invasive ventilation, and thermoregulation. Each of these is vitally important components of early postnatal care for the premature infant, and each impacts the others. Multiple studies demonstrate that the complex interplay of interventions in the first few minutes after birth can cause structural changes, trigger inflammatory or pro-oxidant cascades, and predispose premature infants to life-long complications [9]. Therefore, a standardized approach addressing many of these immediate postnatal concerns will likely improve both short and long-term outcomes in extremely premature infants.

An estimated 8 million infants die each year, worldwide. Over half of these deaths occur in the neonatal period, the first 28 days of life. The large majority of infant

deaths occur in the first week of life, but the highest risk is on the first day [10]. While developing countries with scarce resources are most affected, the impact of infant and neonatal mortality is significant in industrialized nations as well. In 2010, the United States infant mortality rate was 6.1 infant deaths per 1000 live births, which ranked 26th among similarly industrialized nations. Even after excluding births at less than 24 weeks of gestation, the U.S. infant mortality rate was more than double that of Finland, Sweden and Denmark [11]. Compared to 30 years ago, there has been an overall decrease in infant mortality rates on the first day of life, and this has been attributed largely to advances in delivery room management, non-invasive ventilation, and the use of postnatal surfactant. Nonetheless, infant mortality remains highest on the first day of life, and the first 4 hours is the period of greatest risk [12].

Neonatal mortality continues to be a serious issue, then, even in industrialized nations, and the risk appears to be greatest in the first hours after birth. The risks of adversity are amplified for preterm infants by the unique challenges of transitional physiology, immature adaptive systems, and fragile brain structures. Further, differences in outcomes in similar centers cannot be explained by the characteristics of infants alone, suggesting that differences in care may be responsible for suboptimal outcomes [13]. While this is disturbing, the obvious implication is that interventions aimed at improving early postnatal care can improve outcomes in this high-risk population.

3. The newborn transition to postnatal life

Why is the preterm infant at such great risk? Like infants born at term, the preterm infant must transition from fetal to neonatal life in the first minutes to hours after birth, but the risks that accompany this transition are greater for preterm infants than for infants born at term. Anything that disrupts the normal transition to extrauterine life can have negative effects on physiologic function and outcome. Clearance of lung fluid and lung aeration is perhaps the most important early adaptations to postnatal life. The immature lungs, which are fluid-filled in-utero, must provide gas-exchange immediately after delivery. Similarly, oxygen-delivery to the tissues in-utero is dependent on maternal/placental blood flow, but depends on the infant's immature cardio-vascular system immediately after birth. Once born, the immature myocardium must provide cardiac output in the context of increased systemic vascular resistance and significant circulatory shunts. Various hormonal systems are in transition as well, and organ systems that control thermoregulation, vascular tone, glycemic control and neuroprotection are functionally immature in the preterm newborn.

Immature organ function coupled with the stress of physiologic adaptation to early postnatal life increases the likelihood that the preterm infant will be born physiologically unstable. Indeed, extremely premature infants almost universally require cardio-respiratory support in the first hours to days of life. Mechanical ventilation, continuous positive airway pressure (CPAP) and high levels of oxygen are often needed to stabilize oxygenation and ventilation. This, along with persistent fetal circulatory shunts, frequently manifest as hypoxemia and systemic hypotension in the early postnatal period. The preterm infant is also at significant risk of cold stress. Preterm skin is poorly keratinized and vulnerable to radiant heat and water losses. So while the clinical team is focused on ensuring cardio-respiratory stability and appropriate vascular access, the baby must be kept warm, dry and euglycemic.

The preterm brain is especially vulnerable in the early postnatal period [14, 15]. The periventricular germinal matrix is highly vascular, and susceptible to fluctuations in blood pressure and intravascular volume [16]. Postnatal stress and wide swings in blood pressure increase the risk of severe intraventricular hemorrhage

(IVH) [17, 18]. Oligodendrocyte precursors, present in the primitive white matter, are susceptible to oxidative injury and can have life-long effects on neuromotor function [19]. Moreover, endogenous neuroprotective systems which might otherwise protect the newborn from injury are immature and unable to provide such protections in the extremely preterm neonate [20, 21]. These, and other clinical factors discussed below, explain why the preterm infants is so vulnerable in the early postnatal period, and why the concept of a "Golden Hour" protocol is so important for this high-risk population.

3.1 Early physiologic instability and the risk of subsequent adversities

Physiologic depression is common in the newborn period, and heart rate is the most sensitive and reliable indicator of the response to resuscitative efforts [22, 23]. One of the greatest challenges in neonatal resuscitation, however, is the ability to adequately assess the efficacy of resuscitative efforts. Clinicians are unable to accurately assess chest rise from either the head or side of the resuscitation bed [24, 25], and clinical assessment of heart rate by auscultation or palpation is less accurate than assessments with ECG monitoring [26–28]. Further, even normal healthy newborns may not achieve normal oxygen saturation levels until 5–10 minutes of life [29]. These data, and clinical studies in underdeveloped nations, suggest the importance of the early postnatal clinical assessment [30]. In a clinical study in rural Tanzania, which included all live-born, "lifeless", and stillborn infants, early initiation of basic resuscitation interventions significantly reduced birth-asphyxia related mortality. Mortality increased by 16% for every 30 second delay in initiating positive pressure ventilation (PPV) and by 6% for every minute of PPV required [31, 32]. Preterm infants are at great risk, then, of early postnatal physiologically depression, and there is sufficient evidence that efforts to enhance physiologic stability can improve important outcomes.

The Score for Neonatal Acute Physiology-II (SNAP-II), a validated illness-severity score, derives from clinical data obtained in the first 12 hours after birth [33]. SNAP-II includes six indicators of physiologic instability, among these the lowest recorded blood pressure, the lowest serum pH, the lowest temperature, and the lowest recorded oxygen fraction. In a multi-center epidemiologic study from the Extremely Low Gestational Age Newborn (ELGAN) Study Group, mortality risk was significantly greater among infants with an elevated SNAP-II, and the risk was inversely related to the gestational age at birth [33]. Interestingly, mortality risk persisted even after adjusting for gestational age, suggesting that physiologic instability increases the risk of mortality independent of the risk associated with gestational age. In a separate analysis from the same study cohort, blood gas derangements noted in the first 12 hours after birth were associated with several indicators of inflammation, [34] and these were significantly associated with indicators of brain damage [35]. In a recent publication from the same group, physiologic derangements noted in the first 12 hours were associated with neurocognitive dysfunctions in several testing domains at 10 years of age [36]. Overall, the literature suggests that early postnatal physiologic instability increases the risk of adversity in children born preterm, and efforts to improve physiologic instability could mitigate this risk.

4. Delivery room considerations

Any discussion of Golden Hour strategies begins with delivery room management. It is here that the initial changes in transitional physiology begin, and here

that several targeted Golden Hour interventions take place. While only 5–10% of neonates require intervention at birth, neonatal resuscitation is the most common form of resuscitation performed in hospitals worldwide [6]. The Neonatal Resuscitation Program (NRP) exists to guide practitioners in the management of neonates that require help with transitioning immediately after birth. Many institutions employ their own supplementary guidelines and protocols for practice in the delivery room. These focus largely on thermoregulation, advanced non-invasive ventilation techniques, and criteria for administering surfactant. Yet despite the availability of supplementary guidelines, studies have shown that even the most experienced teams will deviate from established guidelines [6]. Like any other skill, neonatal resuscitation and Golden Hour care can be improved with focused practice. Studies have demonstrated that standardized scripts can lead to improvements in care and outcomes. In 2009, Reynolds et al. demonstrated that use of resuscitation checklists, videotaped simulations and team debriefing sessions resulted in improvements in rates of chronic lung disease, intraventricular hemorrhage and retinopathy of prematurity [37].

It is important to recognize that the quality of a resuscitation is only as good as the quality of the resuscitation team. Skilled resuscitation teams improve not only the quality of resuscitation, but the associated outcomes as well. This has been shown specifically with regard to endotracheal intubation [38]. While endotracheal intubation is not unique to NRP or Golden Hour care, this finding suggests that experienced personnel are more successful in high-risk circumstances than less-experienced personnel. Golden Hour care of the extremely preterm infant, especially in the delivery room, should be thought of in the same way. It is not sufficient to advocate for Golden Hour care without first having qualified personnel with the appropriate skillset to perform such care. Moreover, current consensus suggests that interdisciplinary training, team development and the practicing of specific Golden Hour care strategies will not only reduce errors, but improves outcomes [39]. This encompasses strategies such as delivery room simulations with both briefing and de-briefing exercises, as well as content knowledge, technical skills and team building.

4.1 Delayed cord clamping

Delayed cord clamping (DCC), sometimes referred to as placental transfusion, allows the freshly born neonate to remain attached to the placenta, typically for 30–60 seconds. The goal of DCC is to "recapture" as much circulating blood volume from the placental vasculature as possible. This increases the amount of fetal hemoglobin available to the neonate, thus increasing oxygen content, native cardiac output and oxygen delivery. In the premature population, large meta-analyses have demonstrated that DCC has potential benefits for the neonate. A Cochrane analysis published in 2012 concluded that placental transfusion at birth was associated with fewer blood transfusions, better hemodynamic stability in the first few days of life, fewer intraventricular hemorrhages, and fewer cases of necrotizing enterocolitis [40]. Subsequent publications have mostly re-demonstrated similar findings, albeit with differences in certain morbidities and mortality [41]. The theoretical risks of DCC include volume overload and polycythemia, resulting in hyperbilirubinemia, but these risks have yet to be demonstrated in the literature [42].

While there is currently no consensus regarding the use of DCC, it is generally considered safe in term and preterm infants, as long as treatment for hyperbilirubinemia is available. DCC is routinely performed in term neonates, but many institutions also consider DCC for preterm infants born physiologically stable. The

randomized control trial by Tarnow-Mordi et al. in 2017 demonstrated no difference in the combined outcome death or major morbidity at 36 weeks in the delayed cord clamping vs. immediate clamping group [43]. Interestingly, this study found a significant decrease in mortality in the delayed clamping group but no difference in the combined outcome after *post hoc* analyses. In preterm infants, it is important to weigh the benefits of delayed cord clamping *versus* those of delaying resuscitation and other Golden Hour measures.

5. Ventilation and oxygenation

Support of newborn's respiratory system is fundamental to Golden Hour principles. In utero, gas exchange occurs at the level of the placenta, but an immense shift in cardiopulmonary physiology occurs at birth. Respiratory distress is common, especially in preterm infants, due to this physiologic transition to postnatal life. The most immediate concern in the delivery room is proper support the respiratory system [2]. A recent update to Neonatal Resuscitation Program (NRP) guidelines highlights several important changes related to respiratory care [44]. These include recommendations on the use of oxygen in the delivery room, guidance on the use of pulse oximetry, and oxygen saturation targets based on the postnatal age in minutes. NRP now advises against routine endotracheal intubation to suction meconium in infants born through meconium-stained amniotic fluids. Revised guidelines suggest prompt intubation of neonates not responding to positive pressure ventilation and for infants requiring chest compressions for cardiovascular depression [45]. Adherence to NRP guidelines is important, as standardization improves care, but adherence to NRP guidelines does not preclude the use of institution-specific Golden Hour practices.

Preterm infants face various challenges in the transition to extra-uterine life. Respiratory drive is frequently depressed, muscles of respiration are weak, chest wall elasticity is high, and surfactant deficiency is common in infants born preterm [9]. This manifests clinically as decreased functional residual capacity (FRC), poor lung fluid clearance and aeration, and ventilation/perfusion (V/Q) mismatch [46]. In addition, the relatively small caliber of the preterm airways leads to greater airway resistance compared to full-term neonates. To overcome this, and to promote lung fluid clearance and expansion, positive end-expiratory pressure (PEEP) are used with great success to support spontaneously breathing preterm infants [47]. The benefits of early CPAP are numerous, including increased FRC, improved ventilation/perfusion matching, and decreased energy expenditure [48]. The need for endotracheal intubation and exogenous surfactant administration reduces, as is the need for mechanical ventilation [2]. While early CPAP has not been shown to reduce bronchopulmonary dysplasia (BPD) rates, it has been shown to reduce other respiratory morbidities at 18–22 months of age [49].

Finally, oxygen should be used judiciously in the delivery room. Avoiding the extremes of both hypoxemia and hyperoxia during the initial phase of resuscitation is crucial. Preterm infants have reduced capacity for mitigating oxidative stress, and are prone to morbidities like BPD, retinopathy of prematurity, intraventricular hemorrhage and necrotizing enterocolitis [2]. For preterm infants, NRP recommends that a pulse oximeter be applied to the right hand or wrist during the start of resuscitation, and that an initial FiO_2 of 0.3–0.4 is reasonable. While optimal goal oxygen saturations based on postnatal age in minutes are not known for extremely premature neonates, the current ranges for term newborns are recommended [2].

6. Glucose homeostasis and early vascular access

A critical component of Golden Hour care is minimizing the maladaptive patterns that accompany the postnatal transition. The premature neonate is ill-equipped to deal with many of these challenges due to immature organ structure and function. One area of particular concern is energy metabolism and glucose homeostasis. Preterm infants are at increased risk of hypoglycemia due to the limited availability of hepatic glycogen stores and brown fat and are at increased risk of hypoglycemia, and its consequences, than are infants born at term gestation.

The developing fetus receives its energy from the placenta in the form of glucose, amino acids, free fatty acids and ketones, with the majority of glucose accretion taking place during the third trimester [50]. Glycogen storage typically begins around 27 weeks' gestation and increases until roughly 36 weeks. Following birth and clamping of the umbilical cord, the glucose concentration decreases to a nadir at about 60 to 90 minutes. Neonates born extremely premature are especially vulnerable during this period as they have limited ability to mobilize glucose, and lack the cerebral defense mechanisms present in term neonates to combat hypoglycemia [6, 51]. Further, the incidence of hypoglycemia is inversely proportional to the gestational age [52]. Prevention of hypoglycemia is therefore an essential component of Golden Hour care for preterm neonates.

Glucose is the primary substrate for cerebral metabolism, and the deleterious short-term effects of neonatal hypoglycemia are well described. Transient hypoglycemia can produce jitteriness, poor feeding, respiratory distress, and in some instances seizures. The risks are greater in premature infants than in term infants. Of greater concern, however, is the potential for long-term neurodevelopmental impairments associated with even transient neonatal hypoglycemia [51, 53, 54]. It is likely that the risks are even greater for sustained or prolonged hypoglycemia. Preterm infants, and infants born small for gestational age, are dependent on exogenous sources of glucose in the early postnatal period. Intravenous access is therefore critical to resuscitative efforts in this population.

Umbilical vein cannulation remains the preferred method of rapid intravenous (IV) access in preterm infants, but a peripheral IV is often adequate. The principle benefits of vascular access are for administering volume resuscitation, maintenance fluids, glucose delivery, and/or medication administration. The presence of a highly skilled, dedicated neonatal resuscitation team is essential for achieving early vascular access and improved outcomes [55].

7. Thermoregulation

Thermoregulation is essential to newborn homeostasis, and this is especially true for the preterm or growth-restricted newborn [56, 57]. NRP guidelines recommend that the temperature of neonates be maintained between 36.5 and 37.5°C after birth through admission and stabilization [58]. Indeed, we have known since 1907 [59] that admission temperature of neonate is a strong predictor of mortality at all gestational ages [60, 61]. Despite these recommendations, it is common for critically ill term and preterm infants to be hypothermic on admission to the NICU; roughly half of preterm infants in the EPICURE Study were admitted to the NICU with a temperature less than 36.5°C [62]. Temperature dysregulation is associated with Apgar scores less than 7, intraventricular hemorrhage, respiratory distress, hypoglycemia, acid–base imbalances, lactic acidosis, and late onset sepsis [58, 63–70].

7.1 Strategies to maintain a thermoneutral environment

Environmental conditions vary significantly from center to center, and even from room to room. One of the most successful interventions is to increase the ambient temperature of the delivery room or operating room to 77–78.8°F (25–26°C) before the delivery occurs [71, 72]. Some authors have described success by increasing the delivery room temperature to 80°F [37]. Since very preterm and very low birthweight infants are at increased risk of hypothermia, various risk-minimization strategies may be needed, including: covering the infant with heat-resistant plastic wrap, covering the infant's head with a cap, use of exothermic mattresses, stabilization under a radiant warmer, and the use of warmed, humidified resuscitation gases [58, 73]. An updated Cochrane analysis suggests that the best approach to maintaining a thermoneutral environment is not yet clear [74]. Techniques recommended for the term newborn are not universally applicable, but may be appropriate for the mid-to-late preterm newborn, including: pre-warming of linens, drying the infant after delivery, removal of wet linens, swaddling, covering the scalp with a hat/cap, and/or placing the infant skin-to-skin based on the stability of the neonate [58, 75].

Serial monitoring of the infant's temperature is imperative, as there is some risk of hyperthermia using the combination of strategies advocated here [76]. In resource-limited settings, or in the absence of the aforementioned supplies, NRP 2015 recommends the use of clean food-grade plastic bag below the level of the neck, and swaddling the infant after drying [58]. Infants who are hypothermic after resuscitation should be rewarmed slowly [58] to avoid complications such as apnea and arrhythmias. Current evidence is insufficient to recommend a preference for either rapid (0.5°C/h or greater) or slow rewarming (less than 0.5°C/h) of unintentionally hypothermic newborns (temperature less than 36°C) at hospital admission. Additional research is needed.

8. Management of infants at-risk for infection

Neonates are vulnerable to infection before, during and after delivery. Worldwide, neonatal infection contributes substantially to neonatal mortality [77–79]. Risk factors for early-onset neonatal sepsis (EOS) include prematurity, immunologic immaturity, maternal Group B streptococcal colonization, prolonged rupture of membranes, and maternal intra-amniotic infection [80]. Chorioamnionitis is a major risk factor for spontaneous preterm birth, especially at early gestational ages, and contributes to prematurity-associated morbidity and mortality. Chorioamnionitis is an independent risk factor for neonatal sepsis, and is associated with white matter damage and cerebral palsy in preterm infants [81]. Late-onset neonatal sepsis has been largely attributed to Gram-positive organisms, including coagulase negative Staphylococci and *Staphylococcus aureus*, and is associated with increased morbidity and mortality among premature infants [80]. Therefore, the timely administration of antibiotics is recommended for at-risk infants.

Early initiation of antibiotics in the first hour of life when sepsis is clinically suspected has been shown to prevent some serious sequelae of early onset sepsis [82–84]. Challenges in establishing intravenous access in very premature neonates may delay the initiation of antibiotics. Application of Golden Hour quality improvement initiatives, including dedicated personnel for placement of vascular access and better communication with pharmacy can lead to improvements in antibiotic initiation time [85].

9. Environment and developmental support systems

Neuronal development begins as early as the 3rd week of gestation and is largely complete by the 20th week of gestation [86]. Neuronal migration begins in early gestation and continues through early childhood. Synaptic pruning, apoptosis, and patterning are important aspects of brain development, and both prenatal and postnatal events play a role in establishing cortical brain development [86]. Biologic and environmental exposures during these critical periods of development can have adverse effects on brain development. Indeed, events or exposures that interfere with these important developmental processes can adversely affect the organization and function of the developing brain [87, 88].

Exposures common to the NICU have been associated with several indicators of abnormal neurologic function, including poor orientation, low tolerance of handling, poor self-regulation, poor reflexes, and abnormalities of tone [89–91]. Conversely, supportive experiences are associated with stronger brain responses in the developing neonate [87]. A NICU environment that provides developmentally-appropriate cares and supports parental involvement and touch likely improves long term outcomes.

Minimizing the frequency of laboratory blood draws, painful procedures, and interruptions to sleep are simple ways of mitigating exposure to stress that can interfere with normal brain growth and development [92]. Noise reduction, human touch, cycling of light, age-appropriate music, and recordings of mother's voice could also be reasonably placed in a Golden Hour protocol to improve the neuro-developmental outcomes of surviving extremely preterm infants [93]. Neonatal programs caring for high-risk preterm infants should include a developmentally-rich and supportive environment as a core clinical domain for the Golden Hours.

10. Quality improvement and sustained outcomes

The International Liaison Committee on Resuscitation (ILCOR), the American Academy of Pediatrics (AAP), and the American Heart Association (AHA) have published guidelines or recommendations on specific resuscitation practices supported by evidence [58]. Translating this evidence and implementing it into practice requires the development of institution-specific guidelines or protocols that standardize as many elements as possible [71].

Low volume centers should develop thresholds or criteria for timely transfer to higher levels of care in addition to developing regionalization of networks of care. Level III/IV centers also should provide leadership and support for regional hospitals and nurseries that make up their referral base, and it is our hope that this publication can be used as a means of enhancing the flow of information to that end [94–96]. Strategies such as the use of checklists, collaboration/teamwork, consistent approach to care, minimizing variation, [37, 97] simulation- based learning with debriefing; [37] development of steps and checklist in Golden Hour protocol, [85] immediate skin to skin in eligible infant [98] have been described in literature to be effective in providing the caregivers ability to remain organized, aware of time management and provide effective Golden Hour resuscitation measures.

Despite the paucity of evidence supporting specific delivery room protocols, the literature favors standardization of as many elements as possible [71]. The introduction of evidence-based delivery room guidelines has been credited with improvements in the quality of care in a variety of clinical settings [4]. Importantly, utilization of standardized protocols has been associated with improvements in morbidity and mortality [99–101]. Ashmeade et al. focused primarily of 4

processes: interdisciplinary team training to improve communication and care in the delivery room, attention to temperature regulation, respiratory support and timely administration of surfactant, and early initiation of dextrose and amino acid infusion [102].

Developing a protocol for any process or improvement requires careful study, inclusion of key stake-holders, thoughtful protocol development and a comprehensive educational process prior to implementation [103]. Quality improvement, however, requires an ongoing evaluation of systems and processes. This continuous cycle of improvement will lead to improvements in teamwork and collaboration, skills and knowledge, consistency of care, and outcomes [104–106]. Consider using this Golden Hour review as a framework for evaluating systems and processes, for developing clinical guidelines or protocols, and for addressing the challenges unique to your institution [107].

10.1 Teamwork and collaboration

Standardized protocols, technical skills, and repeated training are the cornerstones of successful resuscitation. Emerging evidence suggests that human factors, including team interaction, communication and leadership, play a pivotal role in compliance with protocols and the success of resuscitations [108, 109]. One unit described their experience with implementation of Golden Hour protocol that included the use of realistic simulation-based learning, followed by team debriefing sessions as critical pieces of the implementation process [37]. Finer et al., improved their resuscitation outcomes by identifying opportunities and improving team and leader performance [6]. They utilized Crew Resource Management (CRM), a methodology developed for air crews from the late 1970s that evolved from a careful evaluation of the role of human error in air crashes. Communication and team leaders are the primary framework of CRM.

11. Conclusion

Despite advances in medical care, a large number of preterm neonates remain at risk for significant morbidity or mortality. Golden Hour care of the at-risk premature neonate is a philosophical and team-based and highly specialized care that focuses on the first hours and days after birth. It is devised with the understanding that preterm neonates have unique risk factors based on physiology and immature adaptive systems. Key Golden Hour domains include: optimizing delivery room management of ventilation/oxygenation and thermoregulation, early establishment of vascular access, prevention of hypoglycemia, prevention and treatment of infection, and promotion of a developmentally-focused environment that promotes optimal short and long-term outcomes. The available literature supports standardization at the institutional level. In addition, it is critical to have a dedicated team of providers who regularly practice and hone the clinical skills relevant to Golden Hour care. While this discussion can be used as a framework for developing a Golden Hour protocol, each institution, with its own resource limitations and challenges, must devise an approach that captures not only the needs of their patient population, but the knowledge, skills and experience of the team providing care.

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Conflict of interest

The authors declared that they have no conflicts of interest to disclose.

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