Rui Hu, McMaster University

Dr Douglas DuVal, CAS President, presenting the 1st prize award to Rui Hu

THE FIRST MINUTE OF LIFE: THE DEVELOPMENT AND LEGACY OF THE APGAR SCORE

Dr. Virginia Apgar revolutionized the standard of care in obstetric anesthesia and described a simple, yet effective way of assessing the health of the infant at birth. In fact, a review almost 50 years after the publication of the Apgar score stated, "every baby born in a modern hospital anywhere in the world is looked at first through the eyes of Virginia Apgar".[1]

As late as the 1940s, there was very little attention paid the neonate in the first hours of life. While the obstetrician or midwife were busy attending to the mother, the circulating nurse or residents were relied upon to undertake resuscitation of the neonate if needed. More often than not, trained anesthesiologists were not present in delivery rooms, so the responsibility fell upon residents with little training in neonatal resuscitation. This was a disorganized and haphazard process since there was no standard evaluation of the newborn's transition to life outside of the womb.[2] It was often assumed that little could be done for babies who were small and struggling, so they were left to die. Therefore, from 1930 to 1950, while infant mortality rates improved overall, the survival rates for the first 24 hours of life barely changed.[2] It was clear to Dr. Apgar, an anesthesiologist at Columbia University, that in many cases, newborns could be saved if they were examined closely after birth.

In 1949, Dr. Apgar was the first woman to become a full professor at Columbia University College of Physicians and Surgeons.[3] She also began to study how anesthesia affected mothers and babies, a neglected area of research. Although the origin of the Apgar score is uncertain, common folklore has it that it began during breakfast at the hospital cafeteria in 1949, when a medical student mentioned the need for newborn evaluation. Dr. Apgar picked up the nearest piece of paper imprinted with "Please bring your own trays" and jotted down "heart rate, respiratory effort, muscle tone, reflex irritability, and color" as the five signs that became known as the Apgar score. These encompassed several standard signs used by anesthesiologists to monitor the state of patients. She then rushed off to the delivery suite to test out her theory.[4]

The more likely account came from Dr. William A. Silverman, a retired Professor of Pediatrics at Columbia University and friend of Dr. Apgar.[3] In the 1940s, Dr. Apgar was appalled by the previous neglect of apneic, small for age or malformed newborns. They were listed as stillborn and placed out of sight to be left for dead.

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Table 1. Apgar Score: Signs and Definitions

	Score		
Sign	0	1	2
Heart rate	Absent	Slow (< 100 beats/min)	> 100 beats/min
Respirations	Absent	Weak cry, hypoventilation	Good, strong cry
Muscle tone	Limp	Some flexion	Active motion
Reflex irritability	No response	Grimace	Cry or active withdrawal
Color	Blue or pale	Body pink, extremities blue	Completely pink

Dr. Apgar began to resuscitate these infants and developed a scoring system that would ensure observation and documentation of the condition of each newborn in the first minute of life. Between 1949 and 1952, Dr. Apgar considered several signs that could easily be observed in the newborn.[3] The five that were selected were the ones that could be evaluated without special equipment and easily taught to delivery room personnel. A score of 0, 1 or 2 was given for each sign at 60 seconds after delivery, with 0 being the worst and 2 being the best score (table 1).[5]

According to Dr. Apgar, the importance of the time chosen to assign the score could not be overestimated. She knew from her years of experience as an anesthesiologist that time is crucial and needs to be measured precisely. Sixty seconds was the time that coincided most commonly with maximum clinical depression of respiratory function.[6] She wrote, "only clinicians in anesthesia have learned to live by the second hand of a watch. To others a minute is an unbelievably short interval."[6] She would use an automatic timer, set to 55 seconds, thus allowing a five second evaluation of the five signs.[6]

In July 1953, the landmark paper "A proposal for a new method of evaluation of the newborn infant" was published in *Current Researches in Anesthesia and Analgesia*. The five criteria were used to examine 1760 infants born at Sloane Hospital for Women in New York. The trial demonstrated a correlation between the score at one minute after birth and neonatal death. Children who scored 0, 1, or 2 were considered to be in "poor condition"; children who scored between 3 to 7 were considered to be in "fair condition"; lastly, children who scored 8, 9 or 10 were considered to be in "good condition". The neonate mortality rate in each category was 14%, 1.1% and 0.13%, respectively.[5] The score was especially useful in judging the need for resuscitative measures, such as respiratory assistance.[7]

While the primary goal was to focus attention on the condition of the infant immediately after birth, Dr. Apgar also reasoned that the score could be used to compare various factors influencing neonatal health. She made several important observations that identified different factors that influenced a child's score at birth. These included the type of delivery, the age of the neonate, and mode of anesthesia used during delivery. Several of these observations were later elaborated upon and influenced the practice of obstetrical anesthesia.

At the time, cyclopropane was a popular obstetric anesthetic agent because of its rapid speed of induction, quick controllability of depth of anesthesia, and the possibility of ample oxygenation at all times.[8] However, in the original publication, it was found that infants born to mothers who had regional anesthesia were more vigorous than infants born to mothers who had general anesthesia. This relationship was further elucidated in the second report published in the *Journal of the American Medical Association* in 1958, which analyzed the scores of 15,348 infants.[7] The likely culprit was due to the enhancement of neonatal asphyxia under cyclopropane. While the drugs for regional anesthesia may pass through the placenta, they did not appear to augment the asphyxic depression of the infant.[7] Additionally, cyclopropane had significantly greater respiratory depression as compared with other methods of inhalation anesthesia.[9]

The newborn score allowed for thorough, careful, and objective examination of previous assumptions. For many anesthesiologists at the time, including Dr. Apgar, cyclopropane was a favourite agent for delivery. She had believed the gas to be completely safe and harmless for the infant. When her research indicated that infants born under cyclopropane were significantly more depressed compared to other infants, she was horrified and announced, "there goes my favorite gas!"[10] The obstetrical use of cyclopropane declined dramatically after the research was published, launching the move toward regional anesthesia in obstetrics.

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The use of the newborn score spread rapidly around the world. Other physicians began using it at longer intervals after birth to evaluate how the baby responded to resuscitation. Eventually the 1- and 5-minute score became standard. Greater acceptance of the 5-minute score came when the Collaborative Project, a 12-institution study involving 17,221 children, found it to be a greater predictor of neonatal mortality and future neurological development.[8]

In 1962, Drs. Butterfield and Covey, two pediatricians, published in *JAMA* an acronym to facilitate the teaching of the score. The five signs were renamed appearance, pulse, grimace, activity and respiration to form the Apgar score.[11] Dr. Apgar graciously wrote: "I was surprised and naturally pleased to open my *JAMA* this week to find the epigram [sic] looking at me! Many thanks for […] figuring out this simple teaching device."[4]

The relevance and application of the Apgar score continues into the 21st century. The Apgar score remains the best established index of immediate postnatal health[12]. In 2014, a study published in the Lancet analyzed all births in Scotland from 1992 to 2010. The record of 1,029,307 eligible live birth records showed a strong association of low Apgar score (0-3) to a 359.4-fold increase in risk of neonatal death.[13]

Low Apgar score at 5 minutes was strongly associated with neonatal and infant mortality attributable to anoxia or infection.[13] Interestingly, there was no association of Apgar score with the risk of sudden infant death syndrome (SIDS)[13]. It continues to be an important tool for prognosis and for the identification of risk factors associated with infant mortality.

The Apgar score also signified an unprecedented shift towards methods of structured thinking. Its clear purpose, ease of use, and high predictive value led the way for the development of numerous other clinical scores. Among them are the Aldrete Score, the Glasgow Coma Score, the Trauma Score, and, most recently, the Surgical Apgar Score.[14]

Through her keen sense of observation, Dr. Apgar transformed the fields of anesthesiology, obstetrics and neonatology. The Apgar score is a simple and effective method to guide medical decision making. It enables more consistent identification of neonates at high risk of death in the first minute of life, has prompted development of new clinical innovations, and provides clear feedback on treatment methods. The Apgar score has become an indispensable tool in achieving the remarkable safety of modern child delivery.

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