Measuring Pediatric Resident Performance:
Analysis of NICU Flowsheet Reading Competency

A Thesis Presented to the
Faculty of the School of Engineering and Applied Sciences
University of Virginia
Department of Systems and Information Engineering

In Partial Fulfillment
of the Requirements for the Degree
Masters of Science in Systems Engineering

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May 2005
Approval Sheet

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of the requirements for the degree of
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Abstract

Preliminary studies of physicians’ information seeking behaviors in the Neonatal Intensive Care Unit (NICU) indicate that physicians use the bedside flowsheet to gather much of their information about patients in this environment. The flowsheet is a documentation tool with patient data (vital signs, laboratory results, ventilatory settings, physical exam notes, etc.) on the X-axis and time (in hours) on the Y-axis. Isolating the most clinically relevant data and correctly identifying important trends are two of the key skills physicians must possess. Despite the complexity of interpreting NICU flowsheets and its importance in patient care, residents are not taught how to read the flowsheet in a formalized manner but rather mimic more senior colleagues’ behavior. It is unclear how quickly competence is achieved with this method. This study analyzes the relationship between resident experience and their ability to read flowsheets. Five hypothetical cases were developed and used to test residents’ diagnosis and diagnostic reasoning (variables deemed important in the decision making process) capabilities. Preliminary results indicate an increase in NICU flowsheet reasoning proficiency as residents gain experience. In addition, we found a decrease in performance for residents at intermediate (around 12 weeks) levels of training on some measures. Future tests administered at three other pediatric residency programs in Virginia will add robustness to the statistical models, allowing for more definitive conclusions. Ultimately, the information gained from these studies will be used to develop educational and test modules in the current push for a National competency-based training environment.
Acknowledgements

I would like to take a moment to thank my advisor, Dr. Stephanie Guerlain, for her guidance and support throughout my graduate career. I would also like to thank my other committee members: Dr. Thomas Hutchinson for his insight and life advice and Dr. Patrick Brown for his medical expertise, time, and enthusiasm. This project was funded by a University of Virginia GME Innovation Award run by Dr. Tom Massaro and this material is based upon work partially supported by the National Science Foundation\(^1\) under Grant No. 0092985. The success of the project hinged on the support of the University of Virginia Health System pediatrics department, faculty, and residents. I am grateful for their time commitment and contributions throughout the project. Dr. Phill Gordon’s contributions to the NICU flowsheet were tremendously helpful and greatly appreciated. I would be remiss if I did not thank Matt Gurka for his statistical analysis and contributions. Finally, I would like to thank my family and friends for their unconditional support. I am truly grateful for the education and experiences I have received at the University of Virginia.

\(^1\) Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
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Chapter 1. Introduction

1.1 Problem Definition and Objectives

Forty weeks gestation is considered normal for humans. Babies born between 22 and 37 weeks of gestation (approximately 10% of all births) are considered premature (Goldenberg, 1998). Many of these neonates are extremely sick and require constant, vigilant care. The neonatal intensive care unit (NICU) is a highly complex environment where care is given to those premature babies requiring around the clock monitoring. Two websites: http://preemie.info/cms/ and http://www.preemieconnection.com/ provide excellent pictures and information concerning the fragile environment in which neonates receive care. Babies born prior to 26 weeks or weighing less than 800 grams (454 grams = 1 pound) are significantly more likely to suffer from long term disabilities such as mental retardation, cerebral palsy, blindness, and hearing loss. To preserve the fragile state of neonates, it is extremely important for primary caregivers to accurately interpret neonate data and to act accordingly in this highly volatile environment.

Understanding and interpreting an infant’s clinical condition requires a physician to assess an array of medical data including: physical exam findings, laboratory test results, ventilator settings, treatments, etc., as well as how these data points change over brief periods of time. For a new pediatric intern (physician in training), the task of navigating the maze of patient information in the NICU can be overwhelming. This is due, in part, to the fact that most pediatric interns are not sufficiently exposed to neonatology during medical school, and need to learn an entirely new set of medical knowledge concerning the anatomy and physiology of the neonate. For example, the lungs serve different purposes pre- and postpartum. In-utero, the lungs serve no
functional purpose since oxygen is provided through the mother’s placenta. The ductus arteriosus (Figure 1a), a normal fetal structure, provides a shunt from the right ventricle of the heart to the aorta which allows oxygenated blood from the placenta to flow to the body. The pulmonary arteries, which normally deliver blood to the lungs, are essentially closed in the fetus so that blood is not sent to the lungs. At delivery, a combination of events (expansion of the lungs and high levels of oxygen exposure) occur that promote opening of the pulmonary arteries and closure of the ductus arteriosus (Figure 1b).

Figure 1: Diagrams of the patent (open) ductus arteriosus (1) and the closed ductus arteriosus. Reprinted with permission from the Cincinnati Children’s Hospital Medical Center.

This transition initiates the pattern of blood flow into the lungs that will continue throughout a lifetime. In an ideal setting, this transition from intra- to extra-uterine cardiopulmonary (heart and lung) function occurs seamlessly. For premature infants, however, this conversion often occurs with complications. It is vital for physicians caring for these babies to identify problems quickly and respond accordingly. Subtle changes in a neonate’s clinical condition can point toward significant or even life-threatening consequences.
In order to keep track of changes in a neonate’s clinical course, physicians use a document called the bedside flowsheet. A flowsheet is a form that organizes relevant data (vital signs, medications, inputs, outputs, physical measurements, etc) into a single document, providing a representation of the patient’s condition over time. Each flowsheet can hold up to 24 hours worth of data for a specific infant, and is kept next to the infant’s bed (or in this case, bassinette). The data are entered manually each time such readings are taken. Prior studies (Brown, 2004) have demonstrated that the flowsheet is frequently used by physicians to assess an infant’s clinical condition and is valued because it contains complete and up-to-date patient data. Successful flowsheet reading requires a physician to recognize and isolate the most clinically relevant data, and to correctly identify important trends in those data. However, despite the importance and complexity of this document, pediatric residents are rarely taught how to interpret data from the flowsheet in any structured manner. Rather, most residents learn to obtain information from the flowsheet by modeling the behaviors of fellows and attendings. This process of learning by clinical immersion has been a centerpiece of medical education for years. Recent decreases in the maximum number of hours a resident can work during the week coupled with increasing general curriculum demands, however, have reduced opportunities to learn through traditional outlets. Residents have indicated that the sign out, an important transition of care from one shift to the next, is sometimes rushed, in part, because of new work-hour policies requiring them to be out of the hospital by a specified time post call. Therefore, residents often spend their time ‘putting out fires’ instead of learning the intricacies of newborn management. It seems likely that students and residents would benefit from learning key critical NICU skills such as
recognizing important flowsheet trends through educational programs prior to starting their NICU rotation.

NICU experts are able to assess trends quickly using flowsheets which allows them to obtain a snapshot of the patient without having to read through various caregiver notes. This latter option takes longer and can be difficult to interpret due to documentation discrepancies. Carroll et al. (2003) conducted a NICU documentation study and found at least one error in 62% of the resident’s notes. It is common for residents to refer back to the flowsheet during rounds to gather more information about the recent history of the neonate or if there is a discrepancy between their notes and what is thought to be true.

NICU flowsheets have not been studied systematically despite the above indications that they are commonly used when diagnosing sick babies. A literature review of flowsheets produced journal articles on asthma (Ruoff, 2002), diabetes (White, 2000; Ruoff and Gray, 1999), and pain management (Joyce, Keck, and Gerkensmeyer, 1999). These articles focus mainly on patient’s self-documentation and management of their condition. Clearly, these flowsheets do not serve the same purpose of NICU bedside flowsheets which are directly used to monitor a neonate’s condition. Likewise, there have been no known formal studies indicating how accurately neonatologists read and interpret the data represented on flowsheets or how and when physicians develop the skill set necessary to do so.

This thesis attempts to: 1) Develop a means of assessing proficiency in interpreting data from the NICU flowsheet; and 2) Assess the relationship between residents’ experience in the NICU and their ability to correctly interpret the bedside
flowsheet. It is expected that pediatric residents become increasingly more competent at interpreting information from the bedside flowsheet as they gain more experience working in the NICU.

1.2 Contributions

Experienced neonatologists use the flowsheet as a management tool in the NICU. Development of the necessary skills to accurately read and interpret flowsheets is a main concern for inexperienced residents. Without a doubt, pediatric residents face a learning curve associated with caring for neonates, including mastering the use of the flowsheet. The question is: What does that learning curve look like and how do we speed up the progression of expertise development? To this point, the transition from novice to expert caregiver has not been studied in the NICU. This study demonstrates the learning curve associated with neonatal medicine by systematically analyzing flowsheet reading competency of residents with varying levels of experience.

This study provides valuable insight into how experience influences residents’ abilities to obtain clinically meaningful patient information from a NICU flowsheet. A relationship between experience and performance was established. Expert interviews were used to identify discrete problems in NICU medical education by analyzing when and where residents fail. It is the hope of the investigators to expand the project to include the state of Virginia, and eventually, a national audience. Ultimately, the information gained from this study will be used to develop and test an educational module that will be implemented within the University of Virginia graduate medical curriculum.
Future studies may include analyzing the impact of the medical education intervention on the ability to transfer skills from one intensive care unit to another. This project may also be a catalyst to the establishment of a center for research in medical education at the University of Virginia. It is also possible that the flowsheet itself will be redesigned using insights gained from this study in combination with human factors design principles. The stock flowsheets designed for this study may be validated to the extent that they can be used for NICU competency assessment. Finally, there is the potential to develop an intelligent electronic flowsheet based in part on the knowledge obtained from this study.
Chapter 2. Background

2.1 History

2.1.1 Beginnings
Throughout the early part of medical history many doctors prescribed to the philosophy of natural selection. The mother’s well-being was the primary concern of healthcare providers prior to the turn of the 20th Century, while infants were basically ignored. Infant mortality rates were high, and it was common to have multiple pregnancies before a woman had a successful, healthy child birth. History demonstrates that special care was not given to newborns and they were not mourned if they died within the first week of life (Spitzer, 1996). Industrialization led to more women in the workforce and increases in artificial feeding, child abandonment, and infant mortality. Europe established the Infant Welfare Movement (IWM) in 1870 with the goal of preserving the lives of all infants, even the premature. The movement continued through 1920. As the new century approached, views within the healthcare profession slowly shifted towards the well being of the newborn.

The primary place of birth shifted to dedicated areas for neonates within the hospital during the early 1900’s. In 1900 less than 5% of births occurred in hospitals, by 1921 50% of deliveries occurred in hospitals, and 90% by the 1940s (Lussky, 1999). This may be the single most important change in the structure of the healthcare system as it pertains to the newborn. Now there was a place to monitor and study newborns.

Great strides in the understanding of human biology as it pertains to conditions and diseases of newborn infants facilitated the advancement of technology. Advances in care included: thermoregulation, nutritional and metabolic support, intravenous
alimentation, administration of exogenous surfactant, ventilator support, continuous monitoring, management of infection, microlaboratory determinations, avoidance of trauma, and understanding the developmental needs of the extrauterine fetus. Care givers also began to monitor the newborns’ physical surroundings. Quiet nurseries in Chicago, changes in lighting, and minimizing handling of the newborn and the associated temperature variation were some of the environmental factors that hospitals started controlling. Stephane Tarnier, a Parisian obstetrician, modified a warming chamber used to rear poultry to develop the Tarnier-Martin Couvese for neonates in 1878. The death rate dropped from 66% to 38% among infants with birth weights less than 2000 grams (Cone, 1983). There were also numerous setbacks along the way as pediatricians and researchers developed new technologies and techniques. Blindness caused by over oxygenation, failed incubators, administration of whisky for apnea, strict isolation, limited breast feeding, and regimented feeding schedules slowed the advancement of neonatal care throughout the first half of the 20th Century.

The first intensive care unit (ICU) was established at Kommunehospitalet in Copenhagen in December of 1953 by the Danish anesthetist, Bjorn Ibsen (Berthelsen and Cronqvist, 2003). Berthelsen defined an ICU as a ward where physicians and nurses observe and treat desperately ill patients twenty-four hours a day. Ibsen’s development of the first ICU was a result of his experiences caring for the most critically ill during the polio outbreak of 1952 in Denmark. He noted that concentrating the patients in specially designed wards improved the quality and efficiency of respiratory and circulatory treatments. As a result of his experiences, Ibsen transformed the Observation Room at his Denmark hospital into an intensive care unit. He was not the first to advocate the
need for a specialized area for critically ill patients, however he was the first to implement the idea, and therefore, deserves credit for being instrumental in developing the foundation for future specialized intensive care units such as the surgical ICU and neonatal ICU.

Pierre Budin authored the first neonatal book in 1907 entitled *The Nursling*. Despite some success in caring for newborns, it would be another forty plus years before interest in the discipline would rekindle. Major breakthroughs in the late 50s and early 60s would change perceptions of the premature baby forever. Several different researchers identified the relationship between lung function and a protein-lipid called surfactant. The use of surfactant for what is now known as respiratory distress syndrome (RDS) would save thousands of lives in the years to follow. Thermal regulation became a cornerstone of neonatology around the same time. The term neonatology, defined as knowledge of the newborn, was first coined by Alexander Schaffer in 1960. Mildred Stahlman deserves credit for legitimizing the treatment of neonates through her establishment of the first NICU in the country to use monitored respiratory therapy on infants with damaged lungs at Vanderbilt University in 1961. Neonates were finally recognized as patients within the healthcare system thanks in large part to Virginia Apgar’s efforts in creating the Apgar Scoring System in 1952. The Apgar Score is a method used to evaluate the condition of a newborn infant one minute and five minutes after birth. The infant is given a rating of 0, 1, or 2 on each of five characteristics: color, pulse, reflex irritability, muscle tone, and respiration. A score of less than 7 out of 10 is cause for concern and the infant must be reevaluated every 5 minutes until two consecutive scores of 7 or higher are achieved. If a score of 7 or higher is not achieved,
life-sustaining medical assistance may be needed. This method was one of the first qualitative measurements adopted for predicting the success of the newborn adapting to the post uterine environment.

Despite the major technological advances in the 1950s and 60s, the infancy of the discipline was exposed through inadequate care based on a lack of knowledge. Mortality rates did not decrease despite the obvious advances in neonatal care. Standards of care included: starvation, restricted oxygen, and use of drugs that caused lethal diseases. Clearly, there was room for major improvement in the care for newborns.

Richard Lussky’s article on the history of neonatal medicine (1999) points to the death of President John F. Kennedy’s son in 1963 from RDS as a critical event for the advancement of neonatology. Diseases of the newborn were thrust into the limelight and people began to realize that if it could happen to President Kennedy, it could happen to them. Congress stepped in and declared that neonatal mortality was unacceptably high, increasing funding for neonatal research.

Although the foundation had been developed, it was not until 1975 that neonatology was recognized as a distinct subspecialty. The subspecialty is sufficiently broad in its study of the interaction of normal physiology and disease processes despite being relatively young as a discipline. The NICU is a result of the melding of several different disciplines’ unique techniques and technologies. These disciplines include: obstetrics, premie care, perinatal physiology, and therapeutic trials. The NICU has experienced remarkable growth and advances over the past forty years resulting in amazing improvements in survival rates of the tiniest premature babies (those < 1000g). In 1975, the first class of certified neonatologist included 355 physicians. Approximately
280 new neonatologists have been certified each time the test has been given since then, resulting in 3,688 board certified and eligible neonatologists by 1998. Training has expanded to include upwards of 102 active training programs nationwide including: certified fellows programs in neonatology, the advent of neonatal nurse practitioners and clinicians, and documentation of clinical competency for all nursing staff.

2.1.2 Advances

Although there was progress during the first half of the 20th Century, it was not until the 1950s that premature care was reintroduced as a major concern. There was a reemphasis on thermoregulation, resuscitation, careful feeding, simple and exchange transfusion, and supportive care for respiratory distress. The 60s saw the introduction of electronic monitors, the measurement of blood gases, and antibiotics for sepsis. The 1970s and 80s saw further advances in technology: Umbilical catheters, transducers, microchemistry tests, ultrasound, and improvements in surgical techniques, nutrition, and metabolic support. Family centered care, increased competition, and ethical issues emerged in the late 80s. Finally, the 90s was the so called “decade of the brain”. MRI, PET, and MRS imaging became commonplace. Abnormalities were detected and therefore treated earlier than ever before.

2.1.3 Today

The recently released World Health Report (2005) states,

“Today, more is known than ever before about what determines the health of women and children and about which interventions bring about improvements most cost-effectively. This knowledge makes investment more successful, and withholding care even less acceptable.”

Past efforts have concentrated on developing the most sophisticated high-tech neonatal care. One would be hard pressed to claim that the United States, in particular, does not
have access to the latest research and the best technology when it comes to caring for the neonate. However, statistics continually show that the United States lags behind other countries in many crucial categories. The US ranks 30th in low birth weight rates, 21st in infant mortality rates, and 16th overall in the care of newborns. It is important to note that the free enterprise healthcare system of the United States defers significantly from those countries that rely on government-based systems. Universal health services provide a little bit of support to all citizens (including prenatal care) which dramatically effect outcomes such as infant mortality for the country as a whole. The Japanese have an active maternal and child health program in which a handbook of information is issued to every pregnant woman. Across the board education coupled with having the highest abortion rate in the world (24 per 1000 women of childbearing age), are two of the reasons why the Japanese have the lowest perinatal mortality rate (0.66 per 100 births) in the world (Phelps, 2003). The US could expect similar rates to Japan if it had increased access to abortions, which reduces infant mortality. However, it still does not explain the disparity in health expenditures between the two countries. The World Health Organization devotes a chapter of its world health report to issues involving access to care, healthcare structure, and government involvement (2005). The lower than expected rankings are clearly not a result of shortages in funding. It is commonly known that the United States has one of the highest spending per capita combined with the least comprehensive coverage of any industrialized country. Approximately $28 billion was spent on perinatal care (care around the time of birth) in 1995 which equates to $6850 per mother-infant pair. This figure represents 7% of all healthcare spending by Americans under the age of 65 (Avery, 1999). It is clear that the US has been in a state of
reactionary as opposed to preventative care. Devoting resources to the latest and greatest technology available in the world has minimal impact on cost reduction efforts without investing equal time and effort in attempting to understand the societal issues responsible for producing high risk infants. Stahlman recognized the importance of preventing incurable diseases or conditions before they occur. She wrote in the Journal of Pediatrics (1996),

“We cannot afford to ignore the cumulative results of lifetimes of poor medical and social care on pregnancy outcome much longer. Band-Aid medicine will no longer suffice. We must prevent what we cannot cure.”

Stahlman implored her colleagues at a meeting of the American Society of Pediatrics that same year to look outside the intensive care unit in order to capture what really makes babies sick: accidents, violence, and social and economic issues. After all, neonates are at the mercy of the health of their mothers. Mothers who do not receive adequate prenatal care before, during, and immediately after birth are much more likely to experience neonatal mortality. A 1985 Institute of Medicine report indicated that for every dollar spent in prenatal care, three dollars would be saved over the first year of life and ten dollars would be saved for each dollar spent overall.

Advances in technology and competency have created a double-edged sword. Society has shifted from helplessness to that of immense expectations, assuming that every newborn should survive fully in-tact no matter how premature or sick. Technological advances are occurring at such a rapid pace that many infants who would not have survived a few years ago are now moving through the critical period without deformity. Now, 90% of infants born at 26-28 weeks grow to be healthy (Johnston, Flood, and Spinks, 2003). However, many premature infants survive only to suffer from major debilitating diseases such as cerebral palsy, severely underdeveloped organ
systems, and major brain damage. These children often spend the several days they do survive suffering through painful, highly invasive operations, prolonging the inevitable. The high expectations and hopes of parents often lead to greater heartbreak and disappointment.

In summary, technology and expertise only take us so far. We will continue to experience astronomical costs (in terms of money and mortality) in neonatal intensive care until we successfully tackle social issues such as lack of prenatal care, soaring teen pregnancy rates, AIDS, diabetes, and crack cocaine.

### 2.2 Safety/Background Education

There has been significant recent press concerning the changing curriculum in medical education. Limiting the number of hours one can work during the week combined with the broadening scope of medical education to include a set of core competencies have limited the number of hours that residents spend in a specialized clinical setting such as the NICU. The cutback in hours has limited the amount of time residents have to practice their skills, reducing the effectiveness of immersion training as a viable form of teaching students to become successful doctors. One study indicated that 83% of NICU occupational therapists reported that their primary source of training was on the job and not through formal course work or training programs (Dewire et al., 1996). Many studies have tried to address the concerns of medical education and training by evaluating learning style, motivation, group dynamics, and problem-based versus traditional learning (e.g. Bannister et al., 2003). These studies highlight two major concerns: 1) There has not been sufficient evidence-based research on how doctors make decisions and 2) There is a need for advanced medical education and training beyond
theory, most notably in advanced specialties such as neonatology. In other words, there is a difference between knowing and doing. The tasks, skills, and behaviors required to perform functions of the job are often learned as part of an apprenticeship which conflicts with the model of giving the patient the best possible care (Flanagan, Nestel, and Joseph, 2004). Essentially, Flanagan et al. found that medical and nursing graduates are often unprepared to deal with crises in real work settings, in part, because they lack high fidelity simulation experience. Realistic simulation experiences have similar effects as do immersion techniques without the patient safety risks. The ability to control variables in a simulated environment also allows faculty to exploit gaps in clinical training and decision-making.

At the University of Virginia Health Center, residents spend approximately one month a year in the NICU and/or newborn (transitional) nursery. Currently, most interns’ (first year residents) initial experience with neonatology is their first day in the transitional nursery. The transitional nursery is where older, stable premature babies are stationed prior to being discharged from the hospital. These babies are commonly referred to as feeders and growers. In many cases, these babies are healthy and will be released as soon as they reach a certain weight. Prior to their first day in the nursery, most residents have never seen a NICU flowsheet. Often, the senior doctor (usually a fellow or more experienced resident) will hand the new intern a flowsheet and go over some of the recordable values. From that point on, it is the intern’s responsibility to learn how to best collect and record the necessary information, and most importantly, how to interpret the flowsheet, often with the help of nurses or other residents. Most neonatal learning is done in the NICU as opposed to in the classroom. Interviews of residents and
attendings during this study indicated that the most effective learning occurs in the NICU, and especially on call. The classroom is a good place for knowledge acquisition, but the real learning occurs when residents are required to integrate knowledge and information when making critical decisions in a dynamic environment. It is important for residents to learn and understand the importance of various trends in context, and it is not until they are actually on the front lines in the NICU that they currently get that experience.

2.3 Medical Expertise

There have been countless studies on expert-novice differences. Lesgold et al., (1988) found that expert chess players are superior to novices when asked to recall the position of chess pieces arranged in an expected manner. However, experts are no better than novices at recalling position of randomly placed chess pieces. In other words, experts have a vast experience base and are able to quickly recognize abnormalities, and pick up on informative patterns in data that indicate the need for action. Most likely, they “bundle” individual bits of data into meaningful patterns as they gain a higher level of expertise in a particular domain. The chess board example demonstrates the dependence of recall on the ability to effectively organize knowledge.

In a similar way, the success of a neonatologist relies heavily on his or her ability to quickly notice abnormal patterns of patient data in a dynamic, complex environment (see Appendix B). Experts’ superior performance within a domain can be explained as the result of the comprehensiveness and organization of their knowledge base (Patel, Glaser, and Arocha, 2000) and their reliance on clinical concepts (experience) rather than biomedical concepts (academic/book education) (Verkoeijen et al., 2004). Experts apply qualitatively different knowledge when dealing with a diagnostic task, which is enhanced
through experience. Furthermore, medical experts are able to revert to biomedical knowledge to provide a case diagnosis when necessary.

The three stages of expertise development consist of acquiring basic biomedical knowledge during medical school, gaining clinical experience during residency, and integrating the two, ultimately resulting in knowledge encapsulation. Sometimes an intermediate effect occurs during this progression from novice to expert. The phenomenon occurs when the intermediate relies on an incomplete or unorganized combination of knowledge and experience to make decisions, resulting in a drop in performance compared to novices and experts. The effect is often observed in studies of medical-related performance (Boshuizen and Schmidt, 1992) and (Patel, Glaser, and Arocha, 2000). Although not fully understood, the argument suggest that medical students possess and use biomedical knowledge to formulate diagnoses whereas fellows and attendings use clinical experience in their decision making process. At some point, residents transition from relying on medical training to relying on medical experience. Execution of tasks becomes increasingly easier as medical practitioners gain experience, which allows resource-intensive skills to become automatic, freeing up cognitive capacity for organization and reasoning. This process is often characterized by periods of continuous learning followed by periods of consolidation, where performance suffers. In summary, intermediates are able to consider more alternatives than novices because they have had more clinical experience, yet they are unable to correctly process these alternatives at the level of experts, resulting in a drop in performance.

Expert neonatologists usually do not verbalize their decision-making process when reading a flowsheet. Although the diagnosis may be perfect, the lack of step-by-
step explanation of how they came up with the diagnosis does not provide insight into how the decisions were made nor does it provide a learning opportunity for less skilled residents. Various forms of knowledge elicitation techniques must be used – first to understand when residents learn to become effective neonatologists and second to help improve the efficiency of teaching principles to non-experts. It is important to understand the strategies used by decision makers to deal with complex problems in order to provide insights into where and why problems occur.

Expert interviews and think aloud sessions are two knowledge elicitation techniques that were used in this study to understand neonatologists’ decision-making processes. The goal of these sessions was to gain insight into what practitioners know, and what steps they go through when reading a flowsheet to come up with a diagnosis. Interviewing also provided an opportunity to ascertain how residents learn under the current model of instruction. Key points of these interviews are discussed in Section 4.4.

Since there is variation in hypothesis generation and evidence interpretation at varying levels of expertise, one would assume that there are differences in how and when residents of differing expertise use clinical information. Testing residents that range in experience may demonstrate where differences in knowledge organization are as they relate to flowsheet reading, thereby providing opportunities for advancement of evidence-based medical and health education systems through targeted training.
Chapter 3. Design of Study

3.1 Method

Five hypothetical clinical cases representing different NICU scenarios were created by two faculty pediatricians at the University of Virginia to examine residents’ capacity to interpret data from the NICU flowsheet. The five clinical cases chosen for this study included: surfactant deficiency, liver laceration (acute blood loss), necrotizing enterocolitis (NEC), right mainstream intubation, and an iatrogenic complication of prematurity (metabolic acidosis). Although physicians typically use more than one source of information to make a clinical diagnosis, these cases were constructed with the goal of providing enough information for a knowledgeable neonatologist to achieve a diagnostic choice using only data from the flowsheet. A brief description of the symptoms and likely presentation of each of the conditions and important flowsheet data elements necessary to make an appropriate diagnosis are described in Appendix A.

Three of the cases reflected relatively common scenarios in the NICU while two cases reflect less common diagnoses. In order to present these data, we developed an “abstracted” flowsheet. This abstracted flowsheet includes 81 data elements plus medications presented over an 8-hour time period on an 11 X 17 inch sheet of paper (see Appendix B). The flowsheets also provide a brief patient history, lab values, and any physical exam findings. We felt it was necessary to create an abstracted flowsheet since not every NICU uses the same flowsheet (although all NICU flowsheets follow the general design of patient data plotted against time). By creating a standardized flowsheet design for this study, we hope to ensure that the instrument can be used at multiple institutions while maintaining a level of consistency between subjects. The time period
for the flowsheet data was limited to 8 hours in order to make the data elements fit onto a single sheet of paper and still be legible.

To measure residents’ abilities to interpret data from the flowsheet we developed scoring sheets for each case. These sheets included a list of possible diagnoses for each case as well as a checklist of items from the flowsheet. Diagnostic performance was assessed by asking participants to check the single best diagnosis for each case. Participants were also asked to check the items from the flowsheet that most influenced their diagnostic choice. This was identified as a measure of participants’ diagnostic reasoning and was thought to be reflective of the ability to identify clinically relevant data from a large list of options. To validate the hypothetical cases and flowsheet design, we administered the instrument to seven NICU faculty and fellows. Slight modifications (e.g. temperature adjustments) were made to more clearly represent the clinical diagnosis prior to administering the tests to residents.

### 3.2 Sample

All Pediatric residents at the University of Virginia were eligible to participate in this study. Each resident received an e-mail describing the study’s goals and methods. Interested residents were contacted by phone to schedule one of the six test dates during February and March, 2005. NICU experience was determined by reviewing the number of weeks each resident had spent working in the NICU according to the Pediatric call schedules for the academic years: 2002-2003, 2003-2004, and 2004-2005. Of the 35 residents eligible to take part in this study, 29 were tested. Of the residents that did not participate, one was on maternity leave and the other residents were unable to coordinate their schedules with the testing times offered. Subsequently, two subjects were dropped
from the study because they had transferred into the NICU after their intern year and we were unable to completely assess their amount of NICU call. One additional resident was dropped because call logs of her intern year were unavailable, leaving a total of 26 residents for the study.

The study was gender balanced and included 10 interns, 9 second year residents, and 7 third year residents. Experience in the NICU ranged from 4.5 to 20.4 weeks (μ = 13 weeks, s = 4 weeks) for the tested residents. They were provided food and drinks, but no other benefits were received for participating in the study. Likewise, there were no negative consequences for choosing not to participate.

### 3.3 Testing

Residents were given five flowsheets along with a list of questions to answer. Each resident received a 20 minute orientation covering the purpose of the study and the testing instrument. During this time, a blank flowsheet was given to subjects to familiarize them with the instrument. Residents were told that each answer sheet was exactly the same and that only the data values varied from case to case. Subjects were given the cases one at a time and were allowed to spend a maximum of eight minutes on each case. Once they made their diagnosis, the residents were asked to check the variables that most influenced their diagnostic choice on the corresponding answer sheet.

Follow-up interviews were conducted with a subset of subjects of varying levels of experience (3 interns, 2 third year residents, 2 faculty) to gain knowledge of current training practices and differences in reasoning and knowledge of experts and novices. Subjects were contacted and asked to participate in a 30-40 minute discussion about the cases and their experiences. Interviews were conducted in a one-on-one setting in a
private room. The interviews were audio recorded and later transcribed for analysis. Subjects were required to think aloud while they reasoned through two of the clinical cases (surfactant deficiency and liver laceration). The subjects were asked to pick out concerning and/or relevant data and to hypothesize likely diagnoses at various stages in the flowsheet reading process (e.g. after reading the history, after looking at the vitals, and when they were done). Afterwards, subjects were asked a series of cognitive probe questions (Appendix F) to elicit further knowledge about decision processes, information availability, flowsheet use, and training.

3.4 Scoring

Diagnosis

Residents were given 1 point for correctly diagnosing a case. No points were given or subtracted for an incorrect diagnosis.

Diagnostic Reasoning

To measure diagnostic reasoning, resident performance was compared to that of our sample of expert neonatologists. Items checked by more than 50% of experts for a particular case were defined as “highly relevant”. Those items checked by less than 50% of experts were considered “potentially relevant” and those items checked by none of our experts were considered “irrelevant”.

Positive points were awarded for highly relevant variables checked, negative points were given for irrelevant variables checked, and residents received zero points for potentially relevant variables checked. The score for each individual case was normalized to 20. Therefore, the best possible score for each case was 20 and could be achieved by checking all of the highly relevant variables, none of the irrelevant variables,
and any number of the potentially relevant variables. This score along with the diagnosis were used to analyze the competency of the residents in this domain.

### 3.5 Follow-Up Analysis

General conclusions about knowledge organization, preferences, and training were drawn from the interviews. The interviews were used as a second opportunity to test the validity of the instrument, to gain insight into strategies used by residents of differing experience, and to provide feedback for developing evidence-based decision support tools for NICU training.
Chapter 4. Results and Discussion

4.1 Faculty Results

As expected, the faculty and fellows were able to diagnose the cases effectively. The test was somewhat contrived in that the purpose was to try and guide the decision making process, using the flowsheet as the primary instrument. However, even for the more difficult cases, there were ‘clues’ embedded within the flowsheet that led away from possible alternate diagnoses, which the experts were able to recognize. Six of the seven experts were able to correctly identify all five diagnoses from the list of choices. One fellow correctly identified three of the five diagnoses. The results and a brief discussion with the experts confirmed the validity of the instrument for diagnosing the cases. When asked about the instrument, one expert indicated that ‘the one thing you learn the more you go through training in neonatology is to keep an open mind the whole way’. Overall, the experts thought the instrument was useful.

Average time for experts to complete each case was 5.5 minutes, ranging from 3.5 minutes for Case 4 to 8.0 minutes for Case 5. After completing the diagnosis, the experts were asked to check the items that influenced their diagnostic choice from a list of 66 variables (history, day of life, and estimated gestational age were added after the experts were tested). The variety of variables checked for the five conditions indicated that there were differences in diagnostic reasoning among experts. The following table shows the number of variables checked by each of the experts for the five cases.
Table 1: Number of items checked for diagnostic reasoning (experts).

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty 1</td>
<td>25</td>
<td>21</td>
<td>22</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Faculty 2</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Faculty 3</td>
<td>5</td>
<td>11</td>
<td>13</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Faculty 4</td>
<td>5</td>
<td>14</td>
<td>13</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Fellow 1</td>
<td>8</td>
<td>6</td>
<td>11</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Fellow 2</td>
<td>4</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Fellow 3</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

The average number of checks for each person varied from 5.8 for Fellow 3 to 17.6 for Faculty 1. High variability between experts posed a challenge when deciding how to grade the residents on their ability to reason. From the 66 possible variables, Table 2 indicates the number of variables in each of the three groups: highly relevant, potentially relevant, and irrelevant as explained in Section 3.4 for each of the five cases.

Table 2: Variables grouped per case based on expert diagnostic reasoning.

<table>
<thead>
<tr>
<th>Case 1 - Surfactant Deficiency</th>
<th>Correct Diagnosis</th>
<th>Highly Relevant</th>
<th>Potentially Relevant</th>
<th>Irrelevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct Diagnosis</td>
<td>100%</td>
<td>6</td>
<td>21</td>
<td>39</td>
</tr>
<tr>
<td>Case 2 - Liver Laceration (Acute Blood Loss)</td>
<td>86%</td>
<td>8</td>
<td>17</td>
<td>41</td>
</tr>
<tr>
<td>Case 3 - Necrotizing Enterocolitis</td>
<td>86%</td>
<td>10</td>
<td>19</td>
<td>37</td>
</tr>
<tr>
<td>Case 4 - Right Main-stem Intubation</td>
<td>100%</td>
<td>4</td>
<td>10</td>
<td>52</td>
</tr>
<tr>
<td>Case 5 - Iatrogenic Complication of Prematurity</td>
<td>100%</td>
<td>3</td>
<td>27</td>
<td>36</td>
</tr>
</tbody>
</table>

When discussing the results with the experts, they indicated that they were unsure of what to check. Should they check everything that led them towards the diagnosis?, Everything that led them away from the diagnosis?, Important variables that remained the same?, or A normal band count that indicates that it is not sepsis? Faculty 1, one of the most senior neonatologists, checked significantly more items. Every value was either pointing towards or away from a diagnosis and his interpretation of the instructions led
him to check all the items that he considered when making the diagnosis. During the post
test discussions some of the faculty also indicated that the history was giving away too
much information and some of the data values such as the temperature and FiO₂ values
for Case 1 were slightly off from what they expected to see. Changes were made to the
wording of the diagnostic reasoning instructions, misleading data values, and the history
section in response to the experts’ concerns.

4.2 Resident Results

4.2.1 Diagnosis

Overall, the residents did well on Cases 1 (surfactant deficiency), 3 (necrotizing
enterocolitis), and 4 (right main-stem intubation) and poorly on Cases 2 (liver laceration)
and 5 (iatrogenic complication of prematurity). A breakdown of diagnosis success rate
(by year in residency or number of weeks) does not show a significant relationship
between experience and performance for these cases. The overall diagnosis results for
the residents are shown in Table 3.

Table 3: Residents’ overall diagnostic accuracy for all cases.

<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>100%</td>
<td>15%</td>
<td>100%</td>
<td>85%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Table 3 shows somewhat of an “all or none” phenomenon. The results demonstrate that
the ability to diagnose correctly is based on case difficulty and not experience. Cases 1,
3, and 4 are common and were expected to be recognizable. Case 5 was less obvious and
therefore more difficult. A liver laceration (Case 2) is extremely rare and it is unlikely
that any of the residents have ever seen a neonate present with this condition. Additional
results of resident performance based on experience are shown in Appendix D.
4.2.2 Diagnostic Reasoning

Diagnostic reasoning, on the other hand, did seem to be influenced by experience. For this study, diagnostic reasoning was measured by comparing the variables residents indicated most influenced their decisions with those indicated by the experts. Appendix C contains the score sheets (created based off of the experts’ indications) used to grade the residents’ diagnostic reasoning ability. Bold font and an ‘x’ indicate highly relevant variables, ‘0’ indicates potentially relevant variables, and unaltered items indicate irrelevant variables.

A general, positive trend in residents’ diagnostic reasoning as they gain experience working in the NICU is shown in Figure 2 ($R^2 = 0.1012$, $p = 0.114$, $F = 2.70$).

![Diagnostic Reasoning Graph](image)

**Figure 2:** Graph of overall diagnostic reasoning score versus experience in the NICU.

Case by case results for diagnostic reasoning based on experience in the NICU can be found in Appendix E.
Figure E-1 in Appendix E shows that there seems to be a relationship between experience and number of items checked on the diagnostic reasoning form (intermediate experienced residents checked more on some cases). A resident who does not check as many variables is at risk for scoring worse than a resident who checks more variables, because of the way the scoring system was set up. Therefore, the results were reanalyzed based on the percent of highly relevant and potentially relevant variables checked out of the total variables checked by each resident. The residents’ checks per category were added up across all five cases. The percent relevant values were calculated and plotted against experience in Figure 3 below.

![Graph of percent highly relevant and potentially relevant variables versus irrelevant variables checked based on experience.](image_url)
Calculating percent relevant using the highly relevant and potentially relevant variables together does not show any significant difference between performance and experience. Omitting potentially relevant variables checked provides some interesting results which are shown in Figure 4.

\[ y = 0.0021\exp^2 - 0.0536\exp + 0.6848 \]

and the fit for the Irrelevant second order polynomial is:
\[ y = -0.0013 \exp^2 + 0.0298 \exp - 0.0334 \] \hspace{1cm} \text{Equation 2}

The \( R^2 \) values are 0.1886 (\( p = 0.091 \) and \( F = 2.67 \)) and 0.1388 (\( p = 0.182 \) and \( F = 1.84 \)) respectively.

### 4.3 Discussion

Despite the small sample size, there are some general trends worth exploring. Overall, it appears that diagnosis is a function of case difficulty or more precisely the commonality of the condition being diagnosed. Conditions such as NEC and respiratory distress are common in the NICU, and therefore, much more likely to be recognized and properly diagnosed. On the other hand, most residents have never seen a liver laceration in a neonate and therefore would not even consider it in their assessment of a neonate. Residents’ overall scores on the five cases (Figure 2) trended upward as they gained experience in the NICU. An \( R^2 \) value of 0.1012 is weak and the \( p \) and \( F \) statistics suggest that there is not significance, but we believe that the relationship between experience and diagnostic reasoning capabilities will be strengthened as more residents are tested. The third interesting result was the intermediate effect found when analyzing the ratio of highly relevant variables checked compared to irrelevant variables checked as residents gained more experience in the NICU. The intermediate effect is common within the medical domain. Intuitively, it makes sense that an intermediate effect would present when using a NICU flowsheet as a diagnostic tool. Interns have a limited foundation from which to draw, so they may tend to stick with what they know as opposed to reading too far into things. Second years may know just enough to be dangerous. They have more experience to draw from, but they have not quite been able to properly organize
everything yet. So, although they ultimately get the right diagnosis, they look at more variables and consider more options than their less experienced counterparts. By the time residents reach their third year, they tend to have a better idea of what they are looking for. They are more likely to use past experience to model their future behavior. Third years have better knowledge organization then their less experienced counterparts, and therefore, are able to pick out the most important variables faster and more accurately. Again, the sample size is small and more residents would need to be tested before one could confidently conclude that the instrument used generated an intermediate effect.

The R² value for the highly relevant curve in Figure 4 jumps to 0.3333 from 0.1886 if the resident who had 11.2 weeks of experience was removed, further indicating the need for more subjects prior to making sweeping conclusions. Estimates of the model using the original data and α = 0.05 indicate that 52 additional subjects will need to be tested to achieve 80% power. The model suggests that a stronger linear relationship will result as subjects with less experience are tested.

Time since last neonatal-related rotation was also looked at to determine if there were any correlations between diagnostic reasoning scores and number of weeks since last exposure to the NICU environment. Weeks since last NICU, newborn nursery, and D-Pod rotations were determined for all residents from the residency rotation schedule. The newborn nursery is where all newborns born at term without complication go after delivery. The D-Pod is where mostly former premature infants that do not require the same intensity of care reside until they have grown enough to be sent home. The results showed that there was not a strong correlation between number of weeks since last rotation and the overall diagnostic reasoning score (see Appendix E). Therefore, it
appears that there was no real advantage gained for those who had just been through a rotation prior to taking the assessment test.

### 4.4 Interviews

The main goals of the interviews were to get a sense of the subjects’ knowledge, thought processes, and goal structures that underlie observable task performance, namely reading flowsheets and to get a general sense of the importance of experience in the NICU. Five residents and two faculty members participated in individual interviews. Comments and observations from those interviews (Appendix F) are discussed below.

The first day of NICU rotation is where most residents initially see a NICU flowsheet. None of the residents tested were formally trained on how to read a flowsheet, instead they learned how to interpret them by reading flowsheet after flowsheet and by modeling their seniors. Initially, the flowsheet is just “a bunch of numbers”. It is difficult for interns to piece things together and to pick out important trends in the data which is partially why they look at the flowsheets longer than more experienced residents. Inexperienced residents are not always sure what they are looking for so they follow a step-by-step search process in an effort to figure out what is going on. All of the residents interviewed indicated that picking out trends in data is a key skill. They could not pinpoint when this skill is developed, but by in large, they suspected experience looking at the flowsheet and taking care of sick babies were the most important factors when learning to recognize and interpret trends. As they progress through residency, residents gain experience recognizing trends and are better able to synthesize the story the flowsheet is telling them. They learn what to look for and how to manage neonates as opposed to just being able to recite the etiology and pathophysiology of a disease.
In general, the more comfortable the resident was with diagnosing patients, the less he or she relied on the flowsheet. The more experienced doctors tended to have a relatively clear idea of what was going on after reading the history. Also, they were more comfortable explaining what they would be looking for in the flowsheet to confirm their suspicions as well as what variables they would want to look at to rule out other potential differential diagnoses. In contrast two of the interns went straight to the vitals after reading the history. It is unclear if they took a systematic approach similar to what they would do in a test (which this somewhat emulated and what they are most used to from medical school) or if they were searching for clues buried in the flowsheet to guide them towards a diagnosis.

During testing it was obvious who was using their clinical experience versus who was trying to reason using biomedical concepts. Residents who relied on biomedical concepts spent more time developing their differential diagnosis during the interview because they had to look at a number, determine the normal range of values, decide where that number was in relationship to the range, and match the proper etiology with the value. There working differential was updated (if they have one) and the process was repeated for the next variable on the flowsheet. In contrast, an attending used clinical findings such as the physical exam and the state of shock when describing the liver laceration case while only looking at general trends on the flowsheet. In general, those with more experience were able to come up with a differential prior to looking at the given list of possibilities. In fact, the most experienced attending did not even remember what some of the other diagnoses listed were when discussing the case afterwards because she had never considered them as possible differentials. In contrast, two of the
interns asked to see the list prior to providing their most likely diagnosis. Those without solid differential diagnoses treated it as a multiple choice test, seeking out an answer that would fit with the data in front of them.

Of the residents tested, two are planning on going into neonatology and three plan to specialize in other fields. Interestingly, those that specialize in or are planning on going into neonatology thought that the flowsheets were more important and useful than their counterparts thought despite spending less time using it in the day-to-day management of the neonate. When asked, third year residents and faculty said they spend less than a minute looking at the flowsheet. In contrast, interns said they would spend up to five minutes looking at the flowsheet. Interns are responsible for collecting information off of the flowsheets in preparation for daily rounds. Some see this as an annoying necessity and really the only reason why they look at the flowsheet, but the majority think the process of writing the daily note based off of the flowsheets is instrumental in their pattern recognition development.

Over and over again, experience was trumpeted as the most beneficial way of learning and becoming efficient at flowsheet reading. Hearing what the attending has to say about specific cases, being clinically involved, and having the opportunity to learn from mistakes were sited as the most beneficial learning methods. Attendings do not do as much teaching as they would like. Residents are only exposed to the conditions that present in the NICU during their rotation; therefore they often go through residency without seeing some of the less common conditions. One resident commented that she would have benefited from an overview of common NICU-specific diagnoses. Another said that he did not think it was necessary for the average medical student to get NICU-
specific training, but he thought it was important for everyone to have an understanding of the burden of prematurity. Four out of the five residents interviewed commented that they did not consider liver laceration because they had never seen or heard about it. So even though lecture is not a suitable substitute for clinical experience, the opportunity to at least be introduced to cases may prove beneficial. One resident stated that now the liver laceration differential will cross her mind the next time she sees something similar. This comment suggests that simulated training may be a suitable complement to experience gained in the NICU. Adaptive training tools would give residents a more clinically realistic presentation, which may mitigate some of the difficulties and confusion that occur when transitioning from the ‘knowing’ of lectures to the ‘doing’ of bedside medicine.

In summary, experts think the flowsheet is very important and that we need to teach people how to use it better. Knowledge base broadens as residents mature. Experienced practitioners identify sick kids more readily and they automatically develop a Gestalt of the typical course of action. Experts are more efficient at reading flowsheets because they know what they are looking for and they are better able to tease out what information is important to them. The process of learning and recognizing trends is maximized by actively caring for patients. Residents have indicated that simulated environments that require clinical reasoning may be valuable supplements to time spent at the patient’s bedside.

4.5 Limitations

There are some inherent limitations to the design of this study. Although the flowsheets were designed to be as realistic as possible, the test setting was still somewhat
artificial. Residents were unable to physically look at a sick baby, they were unable to obtain radiological exams, and they were unable to consult with their seniors prior to making the diagnosis. These limitations were acceptable since we were testing the residents’ ability to read flowsheets, not their resourcefulness. However, it was not entirely clear if the instrument was testing knowledge or testing the acquired skill of reading a flowsheet. Post-test interviews were conducted to help answer this question along with basic questions concerning training, personal experiences, and preferences. The ‘all or none’ result for the diagnoses was somewhat unexpected. It is unclear if the cases were so easy (or hard) that everyone got them right (or wrong) independent of experience or if experience would have proven beneficial if more moderately difficult cases were chosen. Also, previous experiences in medical school and desired service after residency were not factored into the analysis. Both of these factors could potentially affect performance. There were not enough subjects in each experience group to make meaningful conclusions on the importance of time since last NICU rotation or desired service after residency when determining the residents’ abilities to read the flowsheet and/or retrieve necessary knowledge concepts from memory for this study. However, this information has been collected post-hoc and will be included in future analysis after more subjects have been tested. Finally, the scoring methodology used for diagnostic reasoning relied on seven experts and seemed to favor those subjects who checked more items since highly relevant variables checked helped the resident’s score more than irrelevant variables checked hurt their score since each irrelevant item checked was worth -1 point while each highly relevant item checked was worth 2 (for 10 highly relevant variables) to 6.67 (for 3 highly relevant variables) points depending on the total number
of highly relevant variables for each case. Analyzing percentage of highly relevant and
irrelevant checks helped mitigate this problem. Factoring in a larger set of experts’
reasoning may help strengthen our scoring methodology of relevant versus irrelevant
variables.
Chapter 5. Conclusion

5.1 UVA

The study at the University of Virginia Health System was widely accepted by both the Pediatrics department and the residents. Participation and enthusiasm was high, encouraging the investigators to continue and expand the study. Initial results are promising, but more testing needs to be done at various institutions to obtain a more representative and robust sample of residents with varying levels of NICU experience to adequately assess the relationship between experience and flowsheet reading capabilities.

Residents performed the same when diagnosing the cases irrespective of their experience. There appears to be a positive correlation between overall diagnostic reasoning score and resident experience. The more experienced residents (by number of weeks in the NICU) reasoned more similarly to the experts than less experienced residents. Interestingly, an intermediate effect was observed when analyzing the percent of highly relevant and irrelevant items checked. This effect will be analyzed closely as more data is collected.

Interviews of current residents, attendings, and faculty provided interesting insights into the use of flowsheets as tools in the NICU. None of the interviewed subjects were trained on the use of flowsheets beyond ‘here it is and this is where you can find it’. Reliance on the flowsheet varies depending on experience, and the perceived importance of such a tool depends, in part, on the resident’s interest in continuing on in neonatology. As a general rule, doctors spend less time looking at flowsheets as they gain more experience. It appears that those who are not planning on going into neonatology find the flowsheet less useful than those planning to become neonatologists.
5.2 Future Studies

The next step is to repeat the study at three other Virginia hospitals with NICUs. There are also plans to include other sites outside of Virginia in the next round of resident testing. Faculty at other institutions will also be tested to increase the robustness of the expert diagnostic reasoning section of the study. Results from UVA residents will be rescored if necessary should the “gold standard” be changed based on the new expert data collected. Data on experience in the NICU during medical school should also be collected to better assess familiarity with flowsheets and the NICU environment in general. Demographic data, especially area of interest for specialization, should be collected for upcoming studies since it is possible that those interested in pursuing neonatology as a career score differently than those pursuing other areas of medicine.

New cases should be developed and tested to determine if diagnosis is independent of NICU experience during residency. Having residents fill out blank flowsheets based on a diagnosis may help reduce potential concerns that a lack of knowledge is driving poor performance. In addition, this method would test residents’ ability to recall information instead of simply recognizing data from a flowsheet. If nothing else, asking residents to fill out a blank flowsheet based on a given diagnosis could be a valuable learning experience for the resident and an effective teaching tool for the faculty. This method could prompt beneficial discussions while ascertaining a measure of the resident’s knowledge of the underlying condition.

5.3 Training Module

The ultimate goal is to develop a highly realistic, adaptive training module for residents. Interviews confirmed that residents usually do not receive any NICU-specific training prior to their first day on rotation in the unit. Every resident interviewed said
they learn best by doing. Lecture and reading are not substitutes for hands on patient care. However, low, medium and high fidelity simulations could be used to teach residents some of the important trends to look for when making a diagnosis and to provide case scenarios for uncommon conditions that faculty simply do not have the time to cover. Simulated environments are also a viable alternative to learning and practicing on extremely precarious babies. Developing these scenarios to coincide with the medical student or resident’s training and learning is the challenge we face as we move forward.
References


**Internet Resources**

http://preemie.info/cms/
http://www.cincinnatichildrens.org/health/heart-encyclopedia/anomalies/pda.htm
http://www.preemieconnection.com/gallery/
http://www.who.int/en/
Appendix A: Case Descriptions

Surfactant deficiency

The lungs begin producing surfactant, a complex protein, at about 24-weeks gestation. The role of surfactant is to equalize surface tension in the air-containing cells in the lung called the alveoli. The mechanical significance of surface tension in the lung can be explained by LaPlace’s law which relates pressure (P), surface tension (T), and radius (R) of the alveolus in the following equation:

\[ P = \frac{2T}{R} \]

The equation demonstrates that the lower the surface tension, the lower the pressure needed to keep the alveolus open, preventing collapse. Without the surfactant, the low volume (and therefore, low radius) at expiration combined with a high surface tension (no surfactant) cause the alveolus to collapse on itself because it cannot maintain the high pressure required to remain inflated. Thus, the role of surfactant is to prevent the alveoli from expanding or collapsing too rapidly due to changes in pressure during the breathing cycle.

A lack of surfactant causes a mismatch between the flow of air in the lungs (ventilation) and the flow of blood in the pulmonary arteries (perfusion). This in turn leads to respiratory distress syndrome (RDS). RDS typically presents at birth in very premature babies and, if untreated, worsens significantly within the first 48 hours of life. Approximately 50% of infants born between 26 and 28 weeks of gestation develop RDS, whereas less than 30% of 30 to 31 week old infants have the disorder (Whitsett et al., 1999). Signs of distress include nasal flaring, grunting, cyanosis which is a discoloration
of the skin due to deficient oxygenation of the blood, and intercostal retractions among others. Decreased breath sounds, diminished pulse, paleness, low urine output, and edema are common observations of an infant suffering from RDS. Blood gas analysis may show hypoxemia (lack of oxygen in the blood) as well as increased levels of carbon dioxide as the disease worsens, but a chest x-ray is needed for confirmation. Fujiwara and colleagues were the first to successfully use surfactant replacement therapy in humans in 1980. Since then, surfactant replacement has become the standard for treating and preventing respiratory distress syndrome.

**Liver Laceration (Acute Blood Loss)**

Blood loss may occur for a variety of reasons from a number of different sources. Two of the most serious sources of blood loss are hemorrhage in either the brain or the gut. Extreme prematurity and/or a traumatic delivery are two common causes of intraventricular hemorrhage. Bleeding from the gut can be the result of laceration of organs during or after delivery.

One way of identifying blood loss is to measure an infant’s hematocrit – a calculated measure of the amount of red blood cells in a given volume of blood. A normal hematocrit at birth is 55-65 mg/dl of blood. A drop in hematocrit during the first few hours of life may indicate blood loss. Other indications of blood loss include: increased heart rate, decreased blood pressure, development of metabolic acidosis indicated by a decrease in bicarbonate, and a pale and mottled (blotchy) appearance. Imaging scans are often used to confirm suspected hemorrhages and to search for other complications that may be causing the bleed. Blood loss can be misdiagnosed or
mistreated if careful attention is not paid to all information available including physical appearance of the neonate.

Necrotizing Enterocolitis (NEC)

Necrotizing enterocolitis (NEC) is a disease of the gastrointestinal tract (intestinal necrosis). “Necrotizing” means causing death to tissue, “entero” refers to the small intestine, “colo” to the large intestine, and “itis” means inflammation. It is estimated that 1-9% of neonatal admissions suffer from the condition with a mortality of 20-30% (Avery, 1999). NEC is the most prevalent gastrointestinal emergency for newborns (Neu, 1996) and is most often seen in premature infants born before 34-weeks gestation and weighing less than 1500 grams. Mortality rates are higher for neonates with an intestinal perforation (a hole in the intestinal wall), which requires surgery, or if there is evidence of shock. Despite the seriousness of the condition, aggressive interventions and preventative measures have resulted in half of NEC survivors leading normal lives after the NICU.

The etiology of NEC is uncertain. The terminal ileum and colon are involved in most cases. In the most severe cases, the entire gastrointestinal tract may be involved. Prematurity and rapid oral feeding have been identified as precursors to NEC in various epidemiologic studies. Other suspected factors include circulatory instability, infection, impaired mucosal defense, and preexisting illness (especially for term infants that present NEC). Mucosal injury appears to be the initial event leading to NEC.

Most premature infants who develop NEC can appear to be otherwise healthy. A sudden change in feeding tolerance and/or gastric motility is an early warning sign for the onset of NEC and should be closely monitored. Other systemic signs include: apnea,
respiratory failure, lethargy, poor feeding, temperature instability, and hypotension as a result of septic shock in the most severe cases. Gross examination of the abdomen often shows a distended and hemorrhagic bowel. Palpable loops of bowel are also an ominous sign. Abdominal tenderness, bile-stained vomit, and bloody diarrhea are other worrisome signs (Schanler, 2005).

The Bell staging criteria provides a uniform definition of NEC based on the severity of the presenting signs and is helpful in comparing cases (e.g. Schanler, 2005). Blood studies, analysis of stool, sepsis evaluation, and radiographic analysis are all used to evaluate a suspected NEC case. Although all of these laboratory reports are good indicators, only an x-ray can clinically confirm a NEC case. Radiographs can show pneumatosis intestinalis, which appears as bubbles of gas in the bowel wall, and is an indicative sign of the early stages of NEC.

Intervention should occur immediately once NEC has been suspected via physical examination, flowsheet analysis, or laboratory results. Care involves close monitoring and supportive care including bowel rest (discontinuation of feedings referred to as NPO) and gentle continuous suction, parenteral nutrition, antibiotic therapy, and correction of metabolic and hematologic abnormalities (Schanler, 2005). Infants are not fed orally for one to three weeks after the onset of NEC, and it is often a month or more before patients attain an adequate oral caloric intake. Infants with perforations require immediate surgery.

**Right Main-stem Intubation or Pneumothorax**

Premature newborns sometimes need assistance with breathing in order to produce adequate ventilation and oxygenation. In many cases, the infant must be
intubated to assist in providing oxygen and removing carbon dioxide from the lungs.

This is done by endotracheal intubation (inserting a breathing tube into an infant’s
windpipe or trachea). The standard technique for inserting an endotracheal tube involves
the use of a straight-bladed laryngoscope, a suction catheter, an appropriate size
endotracheal tube, and an optical flexible Teflon introducer. Optimal positioning for the
tip of the endotracheal tube is in the middle of the trachea (main airway), which varies in
length from 3.5 to 6.0 cm.

If the tube is pushed in too far, it may pass the end of the trachea and end up in a
bronchus – one of two large airways that lead to either the right or left lung. Placement
of the tip of the ET tube in the right main-stem bronchus is one of the more common
errors that occur during intubation. The reason for the tip of the tube to land in the right
as opposed to the left bronchus has to do with the angle that each bronchus makes when it
branches off from the trachea. The left bronchus makes a more acute angle off of the
trachea compared with the right bronchus which makes a more oblique angle (see Figure
A-1). This error leads to ventilation to the right lung and essentially no air movement on
the left.

![Diagram of Right and Left Bronchi](image-url)

**Figure A - 1: Right main-stem endotracheal intubation (EET)**
If a right mainstem intubation has occurred, breath sounds should be louder over the right chest than the left. A chest x-ray should be taken immediately after intubation to ensure proper placement of the tube.

**Iatrogenic Complication of Prematurity (Metabolic Acidosis)**

One complication that can occur in the NICU is providing an infant with more acid than its body can handle. Normally, the body regulates the amount of acidic or basic ions in the blood stream by exchanging molecules of bicarbonate (in the kidney) or carbon dioxide (in the lungs). Although the lungs are capable of exchanging carbon dioxide fairly readily after birth the immaturity of the neonatal kidney (Renal embryogenesis is not completed until the 35th week of gestation) often causes premature infants to become acidotic because they cannot retain adequate amounts of bicarbonate. If an infant has too much acid – either from illness or from receiving too many amino acids in their nutrition – a metabolic acidosis develops. This is evidenced by a normal carbon dioxide level in the context of a low bicarbonate level and a negative base excess. Acidosis is also indicated by an arterial pH less than 7.20-7.25 or a plasma bicarbonate concentration that falls below 16 meq/L (Mattoo, 2005).

Although less severe than other neonatal conditions, untreated acidosis can lead to more substantial complications in the newborn. Short term problems may include inhibition of surfactant production and increases in pulmonary vascular resistance which puts additional stress on the neonate. Longer term problems include organ damage, abnormal neurodevelopment, and increased incidence of seizures and deaths in neonates with a prolonged pH value below 7.05.
Measurements of arterial or capillary blood gases are two methods of determining the acid-base status. The underlying cause of the acidosis may be established by investigating the history, physical examination, and/or lab values. A metabolic screen of the urine and serum for amino and organic acids can confirm metabolic acidosis. Method of treatment for metabolic acidosis depends on the underlying cause. Bicarbonate therapy, alkalinisation of total parenteral nutrition, and THAM (tris-hydroxymethylaminomethane) are three methods used to treat various forms of metabolic acidosis.
Appendix B: Example Flowsheet and Assessment

**History:**
You are called to the bedside to evaluate a male infant (29 wk EGA, BW 1250). The infant was born to a 23 yo G1P1A0 mother. Delivery was precipitated by spontaneous preterm labor. Records show that the infant developed grunting and retractions immediately after delivery. He was intubated and given surfactant in the delivery room then transported to the NICU. Maternal records indicate good prenatal care. No identifiable risk factors.

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<td>Output (cc/kg/hr)</td>
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<th>RR</th>
<th>BP</th>
<th>MBP</th>
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<th>SaO2</th>
<th>IV Fluids</th>
<th>Rate (cc/hr)</th>
<th>IV Fluids</th>
<th>Rate (cc/hr)</th>
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<tr>
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</tr>
<tr>
<td>Abdomen</td>
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<td>GU</td>
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## Blood Gas

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<td>/</td>
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## Medications

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<td>Gentamicin, 3 mg</td>
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<td>06</td>
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</tr>
</tbody>
</table>
History:
You are called to the bedside to evaluate a male infant (29 wk EGA, BW 1250). The infant was born to a 23 yo G1P1A0 mother. Delivery was precipitated by spontaneous preterm labor. Records show that the infant developed grunting and retractions immediately after delivery. He was intubated and given surfactant in the delivery room then transported to the NICU. Maternal records indicate good prenatal care. No identifiable risk factors.

From the list of options presented below, please pick the single best diagnosis for this case.

- Bronchopulmonary Dysplasia
- Necrotizing Enterocolitis (Suspected)
- Cor Pulmonale
- Neonatal Jaundice
- Critical Coarctation of the Aorta
- Patent Ductus Arteriosis
- Hirschprung's Disease
- Pneumothorax
- Hydrops Fatalis
- Primary Pulmonary Hypertension
- Iatrogenic Complication of Prematurity
- Right mainstem intubation
- Imperforate Anus
- Sepsis
- Intraventricular Hemorrhage
- Surfactant deficiency
- Liver Laceration
- Thyrotoxicosis
- Meconium Ileus
- Transient Tachypnea of the Newborn

Comments: Are there any diagnostic options not included on the list that you considered?
What data from the flowsheet helped you to make your diagnosis? Please check the variables that most influenced your diagnostic choice.

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<th>Fluids or Medications</th>
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<tr>
<td>__ Day of Life (DOL)</td>
<td>__ Potassium (K)</td>
</tr>
<tr>
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<td>__ Chloride (Cl)</td>
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<tr>
<td></td>
<td>__ Bicarbonate (measured)</td>
</tr>
<tr>
<td></td>
<td>__ Medications</td>
</tr>
<tr>
<td></td>
<td>__ Intravenous Fluids</td>
</tr>
<tr>
<td>__ History</td>
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<td>__ Day of Life (DOL)</td>
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<td>__ Inspiratory time</td>
</tr>
<tr>
<td>__ History</td>
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<td>__ Inspiratory to expiratory ratio</td>
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<td>__ Ventilator rate</td>
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Comments: Please add any comments that reflect how you thought through the data in this case.
Appendix C: Diagnostic Reasoning Forms

Case 1: Surfactant Deficiency

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<td>__ Medications</td>
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<td>__ Intravenous Fluids</td>
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<td>__ Enteral Feedings</td>
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<td>__ Aspirates</td>
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<td><strong>Vital signs</strong></td>
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<tr>
<td><em>x</em> Ventilator rate</td>
<td></td>
</tr>
<tr>
<td><em>x</em> Peak Inspiratory Pressure (PIP)</td>
<td></td>
</tr>
<tr>
<td><em>0</em> Peak End Expiratory Pressure (PEEP)</td>
<td></td>
</tr>
<tr>
<td><em>0</em> Mean Airway Pressure (MAP)</td>
<td></td>
</tr>
<tr>
<td>__ Sensitivity to trigger breath</td>
<td></td>
</tr>
<tr>
<td><em>0</em> Tidal Volume (VT)</td>
<td></td>
</tr>
<tr>
<td><em>0</em> Spontaneous Tidal Volume (SP VT)</td>
<td></td>
</tr>
<tr>
<td>__ Volume Setting</td>
<td></td>
</tr>
<tr>
<td>__ Minute Ventilation (VE)</td>
<td></td>
</tr>
</tbody>
</table>

**Blood gas results**

| _x_ pH |       |
| _x_ PaCO2 |       |
| _0_ PaO2 |       |
| _0_ HCO3 (Calculated) |       |
| __ Base Excess |       |

**Physical exam findings**

| _0_ Birth Weight |                       |
| _0_ Current Weight |                       |
| __ Previous Day’s Weight |                       |
| __ Head circumference |                       |
| __ Tone |                       |
| __ Fontanels |                       |
| __ Cardiovascular |                       |
| _x_ Respiration |                       |
| _x_ Retractions |                       |
| __ Skin |                       |
| _0_ Color |                       |
| __ Abdomen |                       |
| __ GU |                       |
Case 2: Liver Laceration (Acute Blood Loss)

<table>
<thead>
<tr>
<th>Laboratory values</th>
<th>Fluids or Medications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (Na)</td>
<td>Medications</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Intravenous Fluids</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>Enteral Feedings</td>
</tr>
<tr>
<td><strong>Bicarbonate (measured)</strong></td>
<td>Aspirates</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>Urine output</td>
</tr>
<tr>
<td>Ionized Calcium (Ca++)</td>
<td>Stool output</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>24 hr intake</td>
</tr>
<tr>
<td>Phosphate (PO₄)</td>
<td>24 hr output</td>
</tr>
<tr>
<td>Blood Urea Nitrogen (BUN)</td>
<td></td>
</tr>
<tr>
<td>Creatinine (Cr)</td>
<td>Airway type</td>
</tr>
<tr>
<td>Glucose (Glu)</td>
<td>Airway size</td>
</tr>
<tr>
<td><strong>Hematocrit (Hct)</strong></td>
<td>Airway position</td>
</tr>
<tr>
<td>Bilirubin (Bili)</td>
<td>Airway position</td>
</tr>
<tr>
<td>White Blood Count (WBC)</td>
<td>Ventilation mode</td>
</tr>
<tr>
<td>Platelets (Plt)</td>
<td>Ventilation flow</td>
</tr>
<tr>
<td>Bands</td>
<td>Inspiratory time</td>
</tr>
<tr>
<td>Neutrophils (Neutr %)</td>
<td>Inspiratory to expiratory ratio</td>
</tr>
<tr>
<td>Ventilator rate</td>
<td>Peak Inspiratory Pressure (PIP)</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>Peak End Expiratory Pressure (PEEP)</td>
</tr>
<tr>
<td>PaCO₂</td>
<td>Mean Airway Pressure (MAP)</td>
</tr>
<tr>
<td>PaO₂</td>
<td>Sensitivity to trigger breath</td>
</tr>
<tr>
<td><strong>HCO₃ (Calculated)</strong></td>
<td>Tidal Volume (VT)</td>
</tr>
<tr>
<td>Base Excess</td>
<td>Spontaneous Tidal Volume (SP VT)</td>
</tr>
<tr>
<td>Base Excess</td>
<td>Volume Setting</td>
</tr>
<tr>
<td></td>
<td>Minute Ventilation (VE)</td>
</tr>
</tbody>
</table>
Case 3: NEC

Laboratory values

- Sodium (Na)
- Potassium (K)
- Chloride (Cl)
- Bicarbonate (measured)

Fluids or Medications

- Intravenous Fluids
- Enteral Feedings
- Aspirates

Vital signs

- Temperature
- Heart Rate
- Respiratory rate
- Blood pressure
- Fraction of Inspired O2 (FIO2)
- Oxygen Saturation (SaO2)
- Creatinine (Cr)
- Glucose (Glu)
- Hematocrit (Hct)

Physical exam findings

- Birth Weight
- Current Weight
- Previous Day’s Weight
- Head circumference
- Tone
- Fontanels
- Cardiovasual
- Respiration
- Breath Sounds
- Retractions
- Skin
- Color
- Abdomen
- GU

Respiratory support data

- Airway type
- Airway size
- Airway position
- Ventilation mode
- Ventilation flow
- Inspiratory time
- Inspiratory to expiratory ratio
- Ventilator rate
- Peak Inspiratory Pressure (PIP)
- Peak End Expiratory Pressure (PEEP)
- Mean Airway Pressure (MAP)
- Sensitivity to trigger breath
- Tidal Volume (VT)
- Spontaneous Tidal Volume (SP VT)
- Volume Setting
- Minute Ventilation (VE)
## Case 4: Right Main-stem Intubation

### Laboratory values
- Sodium (Na)
- Potassium (K)
- Chloride (Cl)
- Bicarbonate (measured)
- Calcium (Ca)
- Ionized Calcium (Ca++)
- Magnesium (Mg)
- Phosphate (PO₄)
- Creatinine (Cr)
- Glucose (Glu)
- Hematocrit (Hct)
- Bilirubin (Bili)
- White Blood Count (WBC)
- Platelets (Plt)
- Bands
- Neutrophils (Neutr %)
- pH
- PaCO₂
- PaO₂
- HCO₃ (Calculated)
- Base Excess
- Oxygen Saturation (SaO₂)
- Fraction of Inspired O₂ (FIO₂)
- Fraction of Inspired O₂ (FIO₂)
- Fraction of Inspired O₂ (FIO₂)
- Fraction of Inspired O₂ (FIO₂)
- Fraction of Inspired O₂ (FIO₂)

### Fluids or Medications
- Medications
- Intravenous Fluids
- Enteral Feedings
- Aspirates
- Urine output
- Stool output
- 24 hr intake
- 24 hr output

### Vital signs
- Temperature
- Heart Rate
- Respiratory rate
- Blood pressure

### Physical exam findings
- Birth Weight
- Current Weight
- Previous Day’s Weight
- Head circumference
- Tone
- Fontanels
- Cardiovascular
- Respiration

### Respiratory support data
- Airway type
- Airway size
- Ventilation mode
- Ventilation flow
- Inspiratory time
- Inspiratory to expiratory ratio
- Ventilator rate
- Peak Inspiratory Pressure (PIP)
- Peak End Expiratory Pressure (PEEP)
- Mean Airway Pressure (MAP)
- Sensitivity to trigger breath
- Tidal Volume (VT)
- Spontaneous Tidal Volume (SP VT)
- Volume Setting
- Minute Ventilation (VE)
### Case 5: Iatrogenic Complication of Prematurity

<table>
<thead>
<tr>
<th>Laboratory values</th>
<th>Fluids or Medications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium (Na)</td>
<td>Medications</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Intravenous Fluids</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>Enteral Feedings</td>
</tr>
<tr>
<td>Bicarbonate (measured)</td>
<td>Aspirates</td>
</tr>
</tbody>
</table>

#### Vital signs
- Temperature
- Heart Rate
- Respiratory rate
- Blood pressure
- Fraction of Inspired O₂ (FIO₂)
- Oxygen Saturation (SaO₂)
- Calcium (Ca)
- Ionized Calcium (Ca⁺⁺)
- Magnesium (Mg)
- Phosphate (PO₄)
- Creatinine (Cr)
- Glucose (Glu)
- Hematocrit (Hct)
- Bilirubin (Bili)
- White Blood Count (WBC)
- Platelets (Plt)
- Bands
- Neutrophils (Neutr %)
- Airway type
- Airway size
- Ventilation mode
- Ventilation flow
- Inspiratory time
- Inspiratory to expiratory ratio
- Ventilator rate

#### Physical exam findings
- Birth Weight
- Current Weight
- Previous Day’s Weight
- Head circumference
- Tone
- Fontanels
- Cardiovacular
- Respirations
- Breath Sounds
- Retractions
- Skin
- Color
- Abdomen
- GU

#### Blood gas results
- pH
- PaCO₂
- PaO₂
- HCO₃ (Calculated)
- Base Excess
- Peak Inspiratory Pressure (PIP)
- Peak End Expiratory Pressure (PEEP)
- Mean Airway Pressure (MAP)
- Sensitivity to trigger breath
- Tidal Volume (VT)
- Spontaneous Tidal Volume (SP VT)
- Volume Setting
- Minute Ventilation (VE)
Appendix D: Diagnosis Results

Figure D - 1: Average diagnosis success rate per case, grouped by year of residency.

Table D - 1: Average success rate per case, grouped by year of residency.

<table>
<thead>
<tr>
<th>Year in Residency</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>100%</td>
<td>10%</td>
<td>100%</td>
<td>90%</td>
<td>30%</td>
</tr>
<tr>
<td>Year 2</td>
<td>100%</td>
<td>33%</td>
<td>100%</td>
<td>89%</td>
<td>22%</td>
</tr>
<tr>
<td>Year 3</td>
<td>100%</td>
<td>0%</td>
<td>100%</td>
<td>71%</td>
<td>14%</td>
</tr>
</tbody>
</table>
Figure D - 2: Average diagnosis success rate, grouped by number of weeks of experience in the NICU.

Table D - 2: Average diagnosis success rate, grouped by number of weeks of experience in the NICU.

<table>
<thead>
<tr>
<th>NICU Weeks</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-6 weeks</td>
<td>100%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>60%</td>
</tr>
<tr>
<td>6-8 weeks</td>
<td>100%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>60%</td>
</tr>
<tr>
<td>8-10 weeks</td>
<td>100%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>70%</td>
</tr>
<tr>
<td>10-12 weeks</td>
<td>100%</td>
<td>13%</td>
<td>100%</td>
<td>88%</td>
<td>50%</td>
<td>70%</td>
</tr>
<tr>
<td>12-14 weeks</td>
<td>100%</td>
<td>50%</td>
<td>100%</td>
<td>50%</td>
<td>0%</td>
<td>60%</td>
</tr>
<tr>
<td>14-16 weeks</td>
<td>100%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>60%</td>
</tr>
<tr>
<td>16-18 weeks</td>
<td>100%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>50%</td>
<td>65%</td>
</tr>
<tr>
<td>18-20 weeks</td>
<td>100%</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
<td>60%</td>
</tr>
<tr>
<td>20-22 weeks</td>
<td>100%</td>
<td>0%</td>
<td>100%</td>
<td>50%</td>
<td>50%</td>
<td>60%</td>
</tr>
</tbody>
</table>
Figure D - 3: Diagnosis success rate based on number of weeks of experience in the NICU.
Appendix E: Diagnostic Reasoning Results

Table E - 1: Number of variables checked by category by case for each resident.

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>Highly Relevant</td>
<td>Relevant</td>
<td>Irrelevant</td>
<td>Total</td>
</tr>
<tr>
<td>1302</td>
<td>4</td>
<td>6</td>
<td>0</td>
<td>13.3</td>
</tr>
<tr>
<td>1305</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>6.7</td>
</tr>
<tr>
<td>1307</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>6.7</td>
</tr>
<tr>
<td>1309</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>10.0</td>
</tr>
<tr>
<td>1310</td>
<td>6</td>
<td>8</td>
<td>0</td>
<td>20.0</td>
</tr>
<tr>
<td>1311</td>
<td>6</td>
<td>9</td>
<td>3</td>
<td>17.0</td>
</tr>
<tr>
<td>1312</td>
<td>6</td>
<td>13</td>
<td>1</td>
<td>19.0</td>
</tr>
<tr>
<td>1201</td>
<td>5</td>
<td>11</td>
<td>0</td>
<td>16.7</td>
</tr>
<tr>
<td>1202</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>1203</td>
<td>5</td>
<td>10</td>
<td>4</td>
<td>12.7</td>
</tr>
<tr>
<td>1204</td>
<td>6</td>
<td>7</td>
<td>1</td>
<td>19.0</td>
</tr>
<tr>
<td>1205</td>
<td>6</td>
<td>10</td>
<td>0</td>
<td>20.0</td>
</tr>
<tr>
<td>1206</td>
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<td>2</td>
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<td>3.3</td>
</tr>
<tr>
<td>1208</td>
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<td>8</td>
<td>0</td>
<td>13.3</td>
</tr>
<tr>
<td>1209</td>
<td>3</td>
<td>11</td>
<td>4</td>
<td>6.0</td>
</tr>
<tr>
<td>1211</td>
<td>6</td>
<td>10</td>
<td>1</td>
<td>19.0</td>
</tr>
<tr>
<td>1101</td>
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<td>6.7</td>
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<td>1102</td>
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<tr>
<td>1103</td>
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<td>3.3</td>
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<tr>
<td>1104</td>
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<td>3</td>
<td>3</td>
<td>10.3</td>
</tr>
<tr>
<td>1107</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>14.0</td>
</tr>
<tr>
<td>1108</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>12.3</td>
</tr>
<tr>
<td>1109</td>
<td>4</td>
<td>10</td>
<td>0</td>
<td>13.3</td>
</tr>
<tr>
<td>1110</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>20.0</td>
</tr>
<tr>
<td>1111</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Table E - 2: Average number of variables checked for each case based on year of residency.

<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Case 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Years</td>
<td>11.4</td>
<td>11.2</td>
<td>10.3</td>
<td>10.1</td>
<td>9.4</td>
</tr>
<tr>
<td>2nd Years</td>
<td>13.1</td>
<td>13.7</td>
<td>14.1</td>
<td>13.9</td>
<td>12</td>
</tr>
<tr>
<td>3rd Years</td>
<td>11.4</td>
<td>14.8</td>
<td>14.3</td>
<td>11.8</td>
<td>11.7</td>
</tr>
</tbody>
</table>

Figure E - 1: Number of variables checked for each case based on experience in the NICU.
Figure E - 2: Reasoning scores based on experience in the NICU for Case 1.

Figure E - 3: Reasoning scores based on experience in the NICU for Case 2.
Figure E - 4: Reasoning scores based on experience in the NICU for Case 3.

Figure E - 5: Reasoning scores based on experience in the NICU for Case 4.
Figure E - 6: Reasoning scores based on experience in the NICU for Case 5.

Figure E - 7: Score versus weeks since last neonatal-related rotation.
Table E - 3: Correlation table of experience, diagnostic reasoning, and weeks since last rotation.

<table>
<thead>
<tr>
<th></th>
<th>Experience</th>
<th>Diagnostic</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnostic</td>
<td>0.318048275</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>0.055446879</td>
<td>0.145003</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure E - 8: Scores versus weeks since last neonatal-related rotation.
Appendix F: Interview Questions and Notes

Goals
- Identify abstract nature of knowledge involved – knowledge, thought processes, and goal structures that underlie observable task performance.
- Ultimately accomplish an end goal.
- Identify major events including judgments and decisions
- Probe for situational assessment, critical cues, and potential errors
- Events/Actions/Assessments/Critical Cues/Potential Errors

Questions:

Decision Process/Information Availability
1. How much information do you have prior to approaching the neonate?
2. How do you go about making a diagnosis – what resources do you use?
3. What do you look at first on a flowsheet?
4. Is this the most critical piece of information?/ What was the most important piece of info that you used to formulate the decision?
5. Was there any additional info that you might have used to assist in the formulation of the decision?
6. Were you at any time reminded of previous experience in which a similar/different decision made?

Flowsheet/Education
1. Do you use the flowsheet? How were you trained on it? How is training done now?
2. How is the flowsheet actually used? Is it used as a diagnosis tool or as an instrument for the change in management?
3. What do you expect as you prepare to look at a flowsheet? – Particular mindset/Are you looking for something in particular?
   a. If so, is this something you have developed through experience?
   b. Would a less experienced person have a similar mindset when they are preparing to look at a flowsheet?
4. How long do you look at the flowsheet?
   a. Scan across or down?
   b. What data relationships are important?
   c. Look for critical incidents?
5. When do residents first see the flowsheet? Get their first NICU specific training?
   a. in the NICU
   b. in the classroom
6. In your experience, what has been the most beneficial way for you to learn?
7. How do residents learn now?
8. How should residents be learning in an ideal world?
9. Do senior neonatologists think or act differently than residents when analyzing a case?
10. Why are things difficult…why would they be difficult for a non-expert?
11. Have you found it difficult to switch between forms? Better, worse, indifferent?
12. Do you know anything about the history/evolution of the flowsheet; here, elsewhere?
Attending

Case 1
History – RDS, gestational age, retractions
Respiratory Rate Increase
BP okay
Weened Oxygen then up on Oxygen
Blood gases next – rising CO2 level which can go with RDS
Inspiratory up because of rising CO2
Vents decrease then increase

Physical exam
Retractions and modeled –not good
Bp, HR okay - not shocky

Labs-okay basically, not septic – zero bands

Best diagnosis Surfactant deficiency
Comment-surf deficiency is not really a diagnosis

Case 2
Similar presentation except smaller
Vital signs first
Respiratory went way up, hr way up
BP down
FIO2 same
2 norm saline boluses for low BP
Urine output not as important
Next thing I would look at is blood gases
-4 to -17 = metabolic acidosis, poor profusion from hypertension
Oh, he is on CPAP
Simultaneously looking at labs his cbc not that remarkable nor electrolytes but crit dropped 30 points so
that would account for his low bp and tatacycardia
Exam thready pulses other circled items...basically in shock from bleeding from something
I remember now from going through it the most likely diagnosis is liver laceration causing shock
Checking off variables

1. Usually not the first line person: nurse, nurse practitioner, resident
   Usually one of them comes to me if they are worried with vital signs or labs
   They point something out if they are worried about something in particular
   Often times will go look at the baby cold when just walking around wonder what happened with this
   baby

2. Vital signs in general using the monitor second look at baby then the flowsheet and then exam,
   labs are actually on the flowsheet at UVA so can look at them

3. Look at first page first which is vital signs then pretty quickly look at labs
   sometimes from the history you know what you are looking for otherwise just read from left to
   right with most recent backward on usual rounds sometimes go to day before

Experience: liver laceration case-obviously hemorrhaging to drop crit that much, I guess I never
really considered IVH, did other people think…was IVH even on the list? IVH is generally
clinically silent, they usually do not become shocky and this baby is shocky, aren’t many things
that cause baby to be in shock. If crit hadn’t dropped that much I would have thought sepsis so I
did look at cbc usually not that acidodic and acutely that sick
Bp dropping that quickly and HR going up can only be bleeding
You can be bleeding from your head and only drop your crit a little bit (10 points)
Did it say in the physical exam the baby’s belly distended yes, abdomen blue and tense that is a pretty big tip off that does not happen with IVH and the fontanels is soft and flat
If somebody said it was IVH they did not look at the phys exam and it is also experience because I know the crit b/w 30 and 40 points that just does not happen, residents might think it happens
Huge bleeds you may not even know until the ultrasound

1. Use it less than other attendings that she has observed…cant listen write and read all at the same time during rounds
   reliance on residents to get the info from the flowsheets
   if ever a discrepancy then double check flowsheet or if there are some other questions or trends
   almost never look at flowsheet during rounds to get vital signs
   progress notes not looked at at all
   Not trained on the flowsheet as a medical student rotated through pediatric ICU – here is the flowsheet, every hospital and ICU different and pretty similar to how it is done now, do teach how to interpret something that is abnormal on the sheet
2. Haven’t thought of it as much more of a monitoring and documentation tool, use less as an attending than as a resident
3. 
4. Less than a minute don’t look at nurses physical exam because I am going to do my own plus the nurse will often tell me what they are worried about so I don’t read it
   A less experienced person probably doesn’t know exactly what they are looking for and would probably miss things…I think many residents don’t understand the importance of temperature in the NICU afibrile – in an isolate they are going to be afibrile look at incubator temperature, rely on nurses for this as well
5. …
6. Hearing things from attendings, definitely don’t read it, Lack of hours: once post call resident leaves the on call resident is sometimes just putting out fires and not really thinking as much about what is going on with patient and don’t know patient as well – might miss some things
7. …
8. Ideal way to learn around patients, not in the classroom. I do less bedside teaching than I would like to. The residents have a morning report, noon conference, clinic, call and then I have a lot of other responsibilities too. There is not enough of that time of teaching. We do some didactic teaching, lectures, can’t teach how to examining patients and figure out what is going on by looking at vital signs, labs, and physical exam
9. …
10. Attendings know what to look for and they have experienced rt main stem intubations, etc. After reading the patient history and then look at patient data, I don’t look at every single thing on the list and ask myself could it be this could it be this. I decide based on this what is going on and then I look for the answer on the list. I didn’t even know IVH was on the list because I wasn’t even thinking about it-this is a catastrophic bleed and hemorrhagic shock
   We wouldn’t cover something like this unless we happened to have a baby like this. We just don’t have time to teach everything. We teach the things they are most likely to see and then it is really through experience that you are going to learn
   Being in the delivery room can help anticipate problems
   No substitute for experience
   If resident decides to do neonatology they will have another 4 yrs and they will eventually experience these things or have enough experience with IVH to know that it is not IVH and then go to the list to see what it is
   Come to you? If they are really worried (how acute) they will come to us
   Thing about medicine a lot of times do not know diagnosis but still know what to do
   In real life would have gone and looked at baby and said oh my god that baby’s abdomen is really blue and then they may have thought it was the spleen because they saw a kid come in who got hit by a car who had a problem with the spleen – get x-ray
   Hopefully they would probably get an attending and they would tell them to look at the abdomen
   Important to teach resident to look at patient, a lot of emphasis on technology these days
11. Use flowsheets more at UVA because labs are on the flowsheet, not as used to pulling labs up on computer and do not want to sit at a computer all day would rather interact with nurses, baby, etc. look at vital signs and labs and that’s it
12. Used to be 2 pages now it is 4 pages. It has evolved more into a medical legal document. Lawyers are spending a heck of a lot more time looking at them than doctors do. Worried about a nurse documenting something and not verbally passing it on to the doctors. Hope it is part of the nurses training not to just do that (document and not relay message).

I think the flowsheet is very important and we need to teach people how to use it better.

Here are the diagnoses and put the numbers in the blank flowsheet that you think you would see
Stimulate discussion through matching
Third year 1

Case 1
29 weeker
surfactant unremarkable but noteworthy
1 day old
All pretty normal
MBP higher than normally think would be, based on gestational age and here we would think about 30
certainly not a cardiovascular issue
Surfactant seemed to help initially down to 35% then back up to 65%
That is probably why I have been called to him
Rest of the flowsheet does not really play a role
Electrolytes fine, doesn’t really look like a septic issue, no bands, white count not elevated
Breath sounds coarse but equal, gases stable, PEEP gone up slightly
At this point not a huge respiratory issue, probably a young preemie with young lungs and say lets give him
some more surfactant and see how he does.

Didn’t know why so looking at day of life is important
Going through checklist
Respiratory rate generated by vents usually
Sats say it is a lung problem but ‘not severe’
0% band count indicated it is not an infection since they usually put out something for just about anything

Case 2
29 weeker much smaller 1 day old as well
got surfactant which is not unusual
HR creeping up just looking at the trend, his mean pressure is falling slightly
Sats are fine but requiring increasing amount of FIO2
At this point I would probably say it is more of a cardiovascular issue because change in hr which is pretty
abnormal for these guys and the mean blood pressure is much lower than what I would like granted it could
be some sort of sepsis or something like that but it is pointing me more towards PDA or some
cardiovascular thing going on
Abdomen tense blue certainly significant, not normal, he has thready pulses but his lungs are clear
Looking at his labs then white count of 9 and bands of 1% which is pretty low 1 out of 55 and rest of labs
bicarb 13 Co2 is 13 crit is 22 so it has fallen from 52 to 30 to 22. Definitely a sick child. There are not that
many things that go down that fast that much in that amount of a time. So the thing that I am concerned
about now is a head bleed or a stomach bleed since the abdomen is tense. Certainly those are the things I
would look at first if I were going to do an exam. Then looking at his airway issues pH has fallen 7.17,
ventilating him fine Co2 27, he is on CPAP. So now I know it is a metabolic acidosis, now we need to find
out why. My two guesses are that it is a head bleed or bowel issues – NEC. It would be early for NEC
especially since he hasn’t been feeding since he is 1 day old but a spontaneous perforation would be
another thought but I would probably go with a head bleed because of the crit.
So you are going to go with the head bleed because of the crit?
Because of the crit and then bp, I am not sure which came first. More than likely the head bleed is causing
cardiovascular instability.
…
w/out a murmur I am not thinking PDA it would not explain a drop in Crit
…
The way I was looking at it since never seen it especially in 1 day old. I guess what I was thinking was a
PDA leading to a hemorrhage but also if there is a PDA with a change in pressure it can lead to killing off
quite a bit of gut which can lead to blue abdomen. That is what I was thinking.
…
I certainly would go to what I have seen before
HR caught my eye because of the trend didn’t lead me necessarily one way or the other just told me to look
at the crit and are they compensating, the bp was the big thing.
Day of life is always important…
It is hard to really know exactly what lead me there because it is a Gestalt you figure out…

1. Depends. For the most part you know how old they are and a good estimation of BW and you know their main issues what is going on, especially their lung disease based on how they are being ventilated and usually at sign out they say what their ventilatory status is, what pressures are at, are we weening, steroids, that type of thing. Have an idea if this kid is sick. If you are getting called to kid that you would expect to you probably have a few things in mind. If you are getting called to a kid you are told is well you kind of start from scratch.

2. Depends on how old infant is. On younger infants the physical exam is so tough that it is hard to get a great Gestalt on it to figure out what is going on. Definitely the exam is important especially for the older ones, the feeders and growers. Definitely the nursing staff is important they would rank in the top 3 especially if they have been there over the last 8 hours they can give you a gestalt on what’s going on. Flowsheet is important just looking at the trends.

3. Depends on what you get called for. Based on 29 weeker the first 2 things I look at are the CV system and the respiratory system. And those are the two most common problems that we encounter especially in the young ones. And once we get to the older ones, the feeders and growers, 33-34 weekers probably the most common problem is stomach issues, aspirates, feeding issues so I would probably go more towards that especially if they are not being ventilated anymore the gut and nutrition

4. …

5. Sign out – what is the plan are we trying to ween are we going to stay where we are trying to get a Gestalt of what the plan was from the team for the day

6. When you are an intern all these are are really numbers you don’t have the background to say oh yeah head bleed, PDA. You don’t have the knowledge base yet. Not saying that I do yet. By the time you are a third year you certainly have a much broader knowledge base, you have seen more babies you can understand which kid is sick and which kid isn’t. As an intern you rely much more on upper level, your seniors.

So were you able to eliminate half the problems right off the bat? Potential problems just looking at first few things I saw…BP is stable and doesn’t have band count those two are not the big problems.

1. Certainly. I think that is a big part of how we learn in the NICU and I think that is how we figure out what is going on by looking at the trends over the last few hours.

Were you actually trained on the flowsheet?

No. I think probably what I was told this is where you can find the flowsheet and this is where things are on the flowsheet and that is it. More or less that is how it is still done. Part of it is just the learning process you can’t explain to them look here and here and think about this. I think it is the more you know, the more things you know to look for. And of course things have changed since we have been here.

We weren’t involved in the process…we were taught about any of the new changes…It may slow you down in the process of getting all of the info but once you find it, it is not going to be a problem and the nurses know where the info.

Difference b/w flowsheet in NICU and transitional nursery

2. Both. Certainly in these cases we used them as a diagnosis…I don’t think you would rely just on the flowsheet. If you were thinking surfactant deficiency you would get an x-ray to confirm the results. For this thing (case 2) you would get an ultrasound of the belly and of the head and that would play a role. I certainly wouldn’t say it is a hemorrhage of the head and leave it at that.

3. Nurses come and talk to you, gotten sign out, you are asking the nurse questions to figure out what is going on. It would be a rare instance when you get to the flowsheet and you really don’t know what to look for I guess. Intern? Depends on how much the nurse told them because a lot of the nurses know what is going on. In the beginning of the year probably would get all the info and get a senior…at least I did.
4. Depends on what the issue is. I would jump to the respiratory section first and then the labs. On this flowsheet I looked at labs first because that is what came up first. It depends on how the flowsheet is set up. Timing wise? Most recent back and then if I have a question about how they were doing a couple of days ago I will jump back. Night time rounds could take 20 seconds or 2 minutes looking at the thing if complications.

5. First day taking NICU call. I saw a flowsheet as a medical student I did an AI in the NICU. Most residents probably have not seen a flowsheet prior to going through transitional nursery in the NICU. Training? It is just experience I think. The more you do, the more you learn, the more you see. There isn’t really much of a classroom: noon conference every month or half month on a newborn issue but for the most part learning is on the job, on call. Changes in hours? I don’t think so. You don’t learn much post call day. Doesn’t really stick. The most important think is being on call and that hasn’t changed. We are not there until 3:00 in the afternoon post call but I can’t tell you that I learned much.

6. Take care of babies be on call without having attendings or fellows right there. How much is enough? Probably a month to a month and a half each year. How much do you lose over time? Probably do not lose much as far as knowledge base during your residency. You probably lose some of the technical aspects of it over time when it is not fresh in mind. Shouldn’t really matter once you have spent a month reading a flowsheet you’ve got your pattern down.

7. ...

8. ...

9. I am sure there is. They have seen so many different things. The whole liver laceration thing…I have never seen that so it never crossed my mind even though it was on the list. I guess I did think about the bleeding in the belly but I did not necessarily think about the liver. So I definitely think it would be experience. Take less and less time now because now what to look for you know what the typical course is for that age baby and what affects them

10. So many # don’t know what to do with them as an intern probably don’t get the trend as much. It is not that I don’t care about specific numbers but I look more at the trend to see how things are going

11. Lab values are key on the flowsheet. It would definitely take away from the flowsheet, you would have to look elsewhere for those values
Intern 1

Case 1
1 day old, intubated, surfactant
looks like O2 sats dropping last 3 hours, requiring more O2

Right after reading history concerned that he is not being ventilated properly, tube has come out or he is sick. That is what I would think of...Has pneumonia or something
Based on the flowsheet all I can see is that he is requiring more O2 the exam is not all that interesting other than
Doesn’t look like tube has moved, requiring higher vent settings, blood gases have gotten significantly worse
I would probably order a chest x-ray and check his tube placement again
Other than that I would probably order a second dose of surfactant
What’s leading you towards...pneumonia
On antibiotics. Anyways so would be treating it with that
Being a 29 weeker not going to expect him to be well from a lung standpoint anyway. This is how they react to a dose of surfactant, get better for a little while and then get worse again
Checking items

Case 2
Another premature infant 29 weeks surfactant also 1 day old
(Jumped to physical exam) Becoming increasingly tachypneic, increasing hr, bp down, requires more O2, O2 sats dropping

Anything thinking so far?

No the only thing I can tell right now is that he is decompensating for some reason I don’t know why...with his bp dropping I would guess he is bleeding from somewhere or preterms just drop their bp

Anything it is not? I don’t think it is NEC because hasn’t eaten/1 day old
I don’t know, I would have to look at a list of things
Airway? It definitely could be airway
Abdominal exam is concerning, got a really big drop in ph in just 4 hours so I think it is probably something other than just not being ventilated properly, probably bleeding...into his belly

What does the drop in pH tell you? Oh this is bad...There not oxygenating their blood very well (ventilation or circulation)? Usually with someone on CPAP I would not expect someone with a pH of 7.17...probably more stable from a respiratory standpoint...abdominal exam => something going on with his belly

What would you do? Call a surgeon. X-rays. If that didn’t show me anything I might do an ultrasound on his belly. I would start giving him fluid and order some blood probably.
Knew what answer is supposed to be...Talked about case. B/w liver laceration and Nec, but Nec not very likely...ruling out...probably put that initially

Didn’t pay attention to hematocrit. Claimed to have seen hemat drop that much in a head bleed.

Checking off (skewed)
1. General how old, gestational age, main issues - general overview not day to day theoretically know my babies, but wouldn’t necessarily know much about other babies when on call
2. Most important is what nurse tells me b/c they are usually right. I look at the flowsheet but not as closely as did in this study. And look at the baby of course/exam. X-rays come later
3. 1st case look at vital signs, in most situations I would probably look at vital signs. Sometimes feeding first than vitals. I would look at blood gases but none of the other lab values.
4. Only things that were changing were respiratory things and the history and remember that is the normal course. Case 2 I would have taken one look at the baby and called my senior resident because that is a sick baby.

5. Other than calling the senior...Ordering things all at the same time as calling the resident.

6. Yes I was in the NICU on call when I did this test the first time so it was pretty easy to pull from experience. I would have done terribly if I hadn’t had my second go around in the NICU. Learning wise I learned a lot more in my second go around, felt a lot more comfortable…Being able to interpret a blood gas for one. These diseases were freshest in my mind. If I had to do it now I would probably have to think about it a little more.

1. I wasn’t trained on it. I saw I use it because I have to because every morning I have to write the ins and outs. If I were a senior resident …I would not look at it daily. I look at it because I have to there is no option. It is hard to think of why I look at it because I have to… I just don’t get all wrapped up in the vitals and that sort of things… Why don’t you look at the flowsheet? A lot of times it is wrong. I don’t think they are necessarily the greatest thing…that cant be the only thing

2. Its function is to keep track of a lot of data and to have a lot of data in one place so you don’t have to chase down nurses…but I think it is important to realize that all the info is not necessarily right. Can always scroll back on the monitor. I think it is a way to organize information so you can see a lot of stuff.

3. .

4. Glance through to see if something pops out 30 seconds…I like to sleep more than I like to read flowsheets.

5. Saw one 3rd year of medical school…NICU flowsheets are way more involved 1st rotation in residency, very little classroom training, no experience prior to residency

6. Learned better by doing in all areas of medicine. In the NICU learn disease processes better when I actually have a baby with the illness or when had something that I can actually apply something to. I don’t learn very well by hearing somebody talking about it or by reading about it because I forget.

7. Similarly, but most residents but they probably do a better job of going and reading about something when they see something new, but I still think it is learning by doing and then going and reading about it and then trying to apply it.

8. Definitely think there is room for lecture because there are definitely things you are not going to see in practice enough. In the perfect world is having the experience with the patients

9. As a third year you can kind of step back and look at the big picture so instead of being an intern and looking at all these individual # and saying well right now the temperature is this. Instead you can look over the past three days and so oh well the bp is doing this, do a little less micromanaging and more big picture. The fellows and attendings since they are in the NICU all the time know what to look for. So do you think this is just a whole bunch of numbers that you are trying to piece together? For me it is a lot of # to try and sort through. For a more senior person I think they can be asked a question and know what to look for.

10. Don’t necessarily know what looking for. Lacking experience and not understanding physiology…ventilator, lung stuff…don’t really think I could teach somebody that

11. NICU and transitional nursery have very different flowsheets. Have no idea, it is very obnoxious actually. One says: today’s weight is this yesterday’s weight is this. The other one is completely flipped around. Granted the flowsheets look completely different so it is not like it is a subtle change but I would think if they are both taking care of babies they could be the same everywhere…
Intern 2

1st thing 29 week old male so it is a preterm male which is evident since these are all neonatal cases. My second concern is that this preterm labor. It doesn’t sound like the pregnancy was complicated but you would question what sort of caused it, was it cervical incompetence did the mother have some sort of infection that precipitated this, does the baby have some sort of problem? If so, the body sometimes naturally spontaneously relieve our bodies...My first question is why did she go into preterm labor?

Next he came out at 29 weeks with spontaneous contractions and grunting some of which I would expect since if she went into spontaneous labor they may not have had the opportunity to give steroids to get the baby’s lungs where they would like them to be if he were a little bit older. So the question is why is he grunting and retracting most likely it is that he is premature but there is no mention of meconium in the fluid which I wouldn’t anticipate, but I need to acknowledge possibility and some sort of cardiac malformation I am not really sure. So they intubated him and gave him some surfactant which is the way they would usually do in the NICU. Then I note she had good prenatal care and none of the probable risk factors.

So the next thing in terms of these flowsheets that I tend to think about is the temperature and his temp seems to be fairly well regulated it is obvious that he is in a temp regulated atmosphere looking at temp set there. HR is good. Decent airability. Appears to be having some significant increases in breathing rate but I would anticipate any new infant should be breathing anywhere from 40-60x a minute. He is breathing somewhere between 30 to 55 so somewhat normal since he first came out. His BP all look good to me they correlate with week gestation. The only significant thing I was seeing is that he was on 100% FiO2 when he came out which is what you would expect. He was going down on his oxygen requirement and then started requiring increasing FiO2 to the point of 65% and then he was only sat’ing 90% at room air and I guess the question there is why? And why would this be happening 8 hrs after delivery? Regular fluids at the regular rate. Weighs just about one kilo. 4cc of fluids...appropriate. Fairly decent urine output, stools.  

Base metabolic panel all w/in basic limits accept for an elevated creatinine and elevated buterine. His glucose is good. Decent hematocrit...

Things on physical exam I would be concerned with are that he is tachypenic, coarse breath sounds and intercostals retractions which I am sure correlates back to his increased O2 requirement. Appears modeled getting antibiotics probably because we went sure about sepsis and he is a little person. He is on a vent. Requiring increased PIP. He is becoming more acidodic, retaining more CO2. Decreased O2. Bicarb is becoming elevated more acidodic and is trying to compensate with bicarb. ET tube in same place.

So my guess is...this is a little baby that has received surfactant. My guess is he may need more surfactant. Goes into a discussion of why babies need surfactant. PEEP telling her and coarse breath sounds. BP dysplasia.

Anything else concerned about this point? Could be septic but we are covering that. All seems to be very much an airway issue with him. It could be fluid overload…but I don’t think we are doing any of those things. His color is modeled, that’s not good.

Case 2

So once again preterm male infant 29weeks. Slightly small 900 grams. Delivered by c-section…Maternal seizures…reasoning. Decent Apgars though at 7/8. Got surfactant which is wonderful. Prenatal labs are all normal. Okay so then got D10W at 120 cc/k/day. That is a little concerning. The first day it just seems that he is getting a rate at 4.5 cc/h seems a little high to me for dol 1.

Just trying to think through my NICU stuff and how we increase our fluids but I always thought the first day 100cc/k/d and the concern would obviously be too much fluid. Then you would have a kid with fluids on their lungs which you would have to give laseks for which would not be a good thing.

So temp good. HR going up is sort of concerning 160 to 200. 200 is sort of on the upper end. So at this point he has some sort of sinus tachycardia, at this point I don’t know why. Respiratory rate is also
increasing which is also concerning. So the question is has he gotten his surfactant, is he having problems breathing. I haven’t looked at his physical exam yet. MBP sort of less than what I would like to see 13 is very low to me I don’t know why he is hypotensive. He is also requiring increased O2 and inc FiO2, 45 to 28 to 50 and O2 saturations…so that is concerning. Oh he got two normal saline boluses. One in response to low BP and then one in response to low BP.

Labs: Drop in hematocrit which I would expect…so he is bleeding from some orifice the only reasoning is that it is a huge drop so it is not just delusional. Other labs since I am looking in this direction…Magnesium elevated don’t know exactly why.

Physical exam: I would be concerned that he is hypotensive. For some reason he is going into shock. Tach is a late response for kids any child in shock…losing his blood early on. Tach, thready pulses once again consistent with being hypotensive. Tachypneic prob because he is acidodic w/ bicarb of 13. Good breath sounds which probably means it is not related to the lungs which is all the more reason to believe it is related to acidemia. Abdomen blue in tense so what is going on? He could have a liver lac some sort of spleen where he would be bleeding out. The color indicates that he may have had some spontaneous perforation of the bowel. Why he would have this so early on at 1 day old I don’t know. No PDA. He is on CPAP. Increased respiratory rate high started on amps and gents. Could this be sepsis, possibly very unlikely from the abdominal standpoint. He has something very specific his pH is 7.17 so he is getting acidodic…So my guess is he is bleeding some place so I would probably call the surgeon the question is where?

Continue to give him a normal saline bolus and give him some compressors the only problem is that he is already tach. The problem is you need to do something to drive up his bp. But I would definitely be calling a few people.

Liver laceration. It could be and this is something that I should have mentioned IVH but he has an abdominal thing not a head thing.

Checking: Glucose, WBC normal so important.

Discussion
I had a lot more time to look through them this time. The first time I felt like I was taking a test and that I was rushed. Last time I would finish a case and then I would be like crap I know exactly what that last one was. When I leave I bet it was xyz.

That is one of those cases that when I finished I don’t know what I put, but I bet I didn’t put that…I don’t know what sort of the long haul is for liver lac, I have never seen a liver laceration. But he was bleeding from the belly and how many choices did we have for that. Now if you would have given me spleen lac and liver lac…

Everyone knew it was a bleed or something going on. I wouldn’t be surprised if I put NEC, but the problem w/ NEC is that it is not a bleed so even though a spontaneous perf of the stomach shouldn’t be blue…When I went through the list…I bet that was the answer. I mean logically that makes sense even though I have never seen it. People went with what they knew. Right and that is what I did the first time. But I remember thinking you know what, that would make more sense.

1. I have the flowsheet info. Do I probably approach it that systematically? I don’t know. Maybe after doing this I would probably be more conscientious. Do you think this is beneficial? It could be a matter of maturity going through intern year and being 8 months. It makes a huge difference. I think the whole thought process has changed. It would be interesting to know how answered these questions when I first come in compared how to I answer them now. Training module… It is helpful but as you can see going through these sheets takes some time. I don’t think I am as quick as I need to be.

2. …The first thing, usually get sign out so I know something about this patient. But even if it is my first day on I can pull someone aside and ask them to give me some history about the kid and I
might flip through the chart for a second…After that the first thing I do is look at the kid while
asking a bunch of questions.
3. On this I went systematically through the sheet from top to bottom. If it were a respiratory
problem I would probably jump around respiratory rate, FiO2, O2…vent settings. If someone said
they were modeled…I would jump around place to place on the chart. Would you eventually
cover everything? I think eventually I would look at everything. First things first.
4. …
5. Everything I needed for these cases was there. Obviously in a real situation you could physically
look at the baby and say ill, not ill, really ill.
6. Experience is really, really, really important. This was like taking a test…Test taking skills.
Being out there is not about test taking skills. Every baby is a smidgen different. Out there, I
don’t care if you have seen one, I don’t care if it is 20 years later until you see another one, you
will say that is what it is.

1. Yes in the NICU that is what we refer to. Not trained on it. I guess everyone sees a flowsheet as a
medical student but not the way the NICU’s is set up.
2. I think probably change in management and to support clinical decisions.
3. …Focused and then look at rest of stuff to make sure it is okay
4. Check them multiple times a day. 2-3 minutes in one sitting. Follow ups throughout the day.
5. When I got to the NICU. Probably pretty common experience.
6. I don’t know I think it is multi-fold. Hands on experience with book reading. I don’t think you
can do it all just reading a book. Even if they present it would still be confusing.
7. …
8. I don’t know the answer to that question. I don’t think there is enough years to train…There is no
way you will ever be exposed to everything that you need to be…
9. More quickly, more efficiently. They are able to pinpoint things way more efficiently than I am.
They know who is stable and from what perspective this kid may not be stable…they anticipate,
come up with differential in their mind more quickly than I do.
10. Knowledge base. It is the knowledge and the experience. Seen it, been there and done it. As you
do it your knowledge base grows and you don’t have to revisit it. There is something new and
there is so much that go wrong and can happen. They have far more experience than you can ever
imagine. They can been in the NICU 4 times more than you and that is a big deal.
11. (hadn’t been in transitional nursery yet) same things as others said. I like the NICU sheets, but
that may be because those are the ones I am used to.

General PEDS
Third year 2
Case 1
Main issue is prematurity. Breathing problems, have that info. Probably look at all information, if it were a timed test I might zone in on something, look at the respiratory stuff since that is what is mentioned in the history.

Just glancing at temp it looks okay hr stable, just looking at rr there is an increase in trend in rate so I am going to keep that in mind...Just in the last 4 hrs it seems the baby has increasing O2 requirements so I am going to note that at same time saturation is lower. Urine output looks sufficient, there is not a whole lot information there so I am going to move on and look at the labs. The gases are probably what is going to help me but they do have electrolytes, they look pretty okay. I am just looking at vent settings to see if they had to make any adjustments and it looks like they had to go up on the rate and pressure at the same time. Gases are getting slightly worse. Looks like the baby is retaining CO2. ET tube and everything looks the same so I don’t expect that to be any different. Physical exam baby breathing fast and having retractions so it seems to be a respiratory issue. The baby is already on antibiotics and is not having metabolic issues so that is why I am thinking respiratory.

So I am thinking due to prematurity so this baby probably needs another dose of surfactant and I would probably get a chest x-ray to rule out pneumothorax or something like that. Vitals to electrolytes to physical exam. Is this how you would normally do it or is it just because of the way this flowsheet was organized? Probably the way the flowsheet was organized. What would normal happen is the nurse would come and say____. And then that would make me automatically go to the baby and look at the baby. Usually I will probably just eyeball the baby first. It is not as nicely laid out as it is here. This information will already be given to us here (vitals) (verbally)...But in the morning if I were rounding I would kind of do what I am doing now. I would look at everything and look at the vitals first and look at the baby last unless they are huffing and puffing.

Were we supposed to check one thing for everything because I wasn’t really sure… Just now I checked the ones that led me to the diagnosis. The bicarb was one thing I did look at to make sure it wasn’t metabolic acidosis but I didn’t necessarily check it.

Case 2
Just get a story about a premature baby again who is already intubated.

Just going to look through the vital signs: temp looks okay, HR increasing that is the most alarming thing jumping out at me, and then I notice the baby is breathing fast so the baby is lot sicker than I thought from just reading the story and the BP is dropping which is making me even more worried about the baby. MBP is also dropping increasing in Oxygen but not as much as previous case. Concerned losing blood somewhere, basically going into shock. I look at the baby: pulses are thready, skin is cool, mottled, the belly looks no bowel sounds, blue and tense that looks bad too. Now I am thinking NEC because of the belly exam. Or sepsis. Platelets and hematocrit look okay so now I am looking at Bicarb. Baby does have some metabolic acidosis. Baby’s initial hematocrit was 52 and 6 hrs later it is 22 so I know he is bleeding from somewhere. Just quickly looking at gases baby has a lot of Base Excess. This is a premature baby so I am worried about bleeding from somewhere, hematocrit dropping so much lower. IVH which can happen or NEC but that could just be poor profusion to the belly so now the belly is a secondary reason. I would probably get a belly picture give the baby fluid or blood. The baby is already on antibiotics. I would get a head ultrasound because I am worried about a head bleed.

I was thinking that it was IVH and then NEC as a consequence of it. I don’t know. Is there anything else you would do at this point other than two ultrasounds? Probably just give blood. Probably give another normal saline bolus and then order some more blood.

Now I think it is NEC. Well it is really liver lac. Obviously blue and tense was really important and the drop in hematocrit…Why would a baby get a liver lac? I have never seen a liver laceration and I know IVH can happen pretty abruptly. Maybe hematocrit doesn’t drop that low but I know it can happen quickly. This did not make sense but I thought it was because there was so much bleeding and then have poor profusion and then leading to NEC. Me talking…
1. We have a lot of info already, the nurses usually have a good sense of what is going on. Occasionally once in awhile you might something that is new to you. There are so many babies so they grab us and tell us that they are concerned about the baby. Maybe during rounds we come across something by accident.

2. Beside nurse probably just the flowsheet and the person working the night before. *What about the 2nd case where the baby is obviously pretty sick?* Well I guess if I was just coming on I would probably get serial labs and then get them more frequently if the baby is sicker.

3. In the morning it is to fill out our daily note which kind of dictates how we look at it…Otherwise based on what the nurse says. Usually look at the baby first.

4. …

5. …

6. When I first came to the NICU I probably didn’t even know what IVH and not even think about that as a possible option so I do think that you probably do base a lot of that on your experience

1. Yes sometimes if I want to check up on something…If I saw the heart rate at 175 going from 160 to 175 I wouldn’t think much of it but I would check back later to see if the trend kept going. Before I first started in the NICU the upper year gave us a NICU preview. So when she sat down with us she didn’t actually bring the flowsheet but she talked to us about what info to gather from the flowsheet. So she didn’t really show us how to use it but she said in the morning you need to collect the vital signs and what data to collect but once we actually got there we just had to figure it out. This is nicely printed but sometimes it is not as clean-cut and sometimes you will miss something that you didn’t pick up in the morning and the attending will pick them out…kind of by error…There are a lot of acronyms used and if you don’t know what they mean…I think that even if you did a little intro session of how to read flowsheet I think eventually you will learn by doing it…I think it would be nice if someone went over it

2. If you are including the labs I guess it could be more diagnostic but not all the labs are there so sometimes have to go find own stuff. Nurses do write some stuff but I usually do my own. I think definitely management…I think both.

3. The whole scanning thing would be in the morning. I would probably go look at the baby and then zone in at what I am looking for.

4. A couple of minutes

5. Actually fourth year med school I did do a little step down NICU. No classroom stuff.

6. I think just by doing it. Reading it. Look at the flowsheet over and over.

7. …

8. A few lectures on the most common diagnoses you find in the NICU that you don’t really find anywhere else and what to look for…I think that would help you to keep it in the back of your mind…Just a quick preview or overview…In the real world would get a bunch of studies and figure it out pretty quickly…

9. You know exactly where things are. The more experienced you are the better you are at picking out trends and patterns.

10. The kids are sicker than on the floor just in general. Multiple problems. I think it is pretty tedious as far as the amount of info that is out there that you have to gather. And because there is so much you have to tease out what is important and what is not important especially if you are taking care of lots of babies. As years go by getting better at that and sort of realizing that something is wrong

11. (Has not done NICU here) nothing really interesting in this section
Intern 3  
Case 1  
Reading history…SO I see preterm labor in a baby who is 1250 g and 1 day old, I start thinking of infectious causes of things because preterm labor is often caused by infection that we don’t really recognize. Grunting and retractions immediately after delivery. I think of RDS and infection, cardiac issues as well differential at that point. Intubated and giving surfactant good prenatal care…Good prenatal care means infection goes down on my list of differentials but it is still there. Surfactant brings down the risk of severe RDS but certainly doesn’t eliminate it. Day old 1250g VLBW infant.

Go to the flowsheet and go to the first settings often temp is not a big deal because they are on settings. RR is normal for a kid that old bp is right on. When I look at FiO2 I always look at the trend and where they are going. We weened which is what you see with surfactant but then the kid is back up on FiO2 requirement and his sats are lower. My differential at that point starts working more respiratory. I am thinking the kid needs more surfactant often kids need multiple doses. I also think about iatrogenic causes like pneumothorax which you can see although this decline is a little more gradual and pneumothorax tends to be an immediate decline. Infection is still there pneumothorax or sepsis could cause this. Haven’t feed the kid and his urine output he has voided w/in first several hours of life don’t worry about urine output until later in life.

This is a little bit artificial because in reality the first thing I would do is look at the baby. So taking a step back for a second: he is tachypneic, he has equal breath sounds which to me rules out pneumoth almost right away he is retracting which could be sepsis, RDS. Color mottled which means he is not cyanodic which means he is not profusing well which can be a sign of sepsis as well. He has a soft abdomen so I don’t think he has had an abdominal perf. He is on antibiotics already which is what most kids get to begin with so he is septic he is on antibiotics already so that lowers my differential. I think it is a primary respiratory problem. First I am going to look at his blood gases before I look at anything else. He is becoming progressively more acidodic. This is a respiratory process have to look at PCO2 rising. Bicarb is not going down, less of infection. Looking at, ET tube hasn’t moved, position is right. His settings, we have gone up on his settings, his pressure, to try and vent him. We have had to go up on his O2 as well. To me at this point he is having RDS. He needs more surfactant…(describes what is being needed).

Then I look at the labs and sometimes they are the least useful except for the blood gases. Typically they would be the last thing I would look at. Nothing there of significant interest. In this kid I would say he has RDS and he probably needs another hit of surfactant. He certainly meets the criteria for it being greater than 40% FiO2 and ventilation settings.

So physical exam first then very first vital signs then blood gases then labs if necessary, is that right? Absolutely, look at the baby first and sometimes I have to remind myself to do that. Look at the baby first without looking at the flowsheet and then you look at the most recent set of vitals then you want to get a trend for the vitals because that can tell you a lot as well. Then I will look at the blood gas because these kids are getting so many early on and then the labs are kind of the last thing.

First thought was probably respiratory possibly sepsis? Is your inclination to go for confirmatory evidence or do you want to rule out?... I think the most likely diagnosis is RDS but you always have to have infection in the back of your mind. It is one of those knee-jerk reactions in neonatology of which there are many, but infection can cause pretty much any symptom so you definitely want to rule that out and when I saw that the kid was on amp and gent I am less. I care about the infectious issue less.

Checking what was most important…

Case 2  
Reading history…Maternal seizure, hmm. So why did the mom have a seizure? May or may not be important. Mom could be a cocaine addict which is something you would want to know…Baby received surfactant which all babies would as part of an oxygen requirement.
Always look at prenatal labs. Usually generally here you have enough time to get the history and this is not a place where you get a lot of women who walk in with nothing. If you were in a city you may have more of that. Usually you don’t have an excuse here.

Maternal seizure is interesting, pre-eclampsia, drugs, list of drugs. Obviously mom is having some…if she is having that kind of c-section. Small. Come down and look at the baby who is now 6 hrs old. Just looking at the baby strikes me as thready pulses and again the profusion is poor and that could be from a # of things septic shock or primary cardiac issues or again it could be respiratory. If pulses are poor means profusion is poor means sepsis or some sort of cardiac issue. Rest of physical exam…Interesting the abdomen blue and tense w/out bowel sounds. No bowel sounds is not normal, not scary, but blue and tense is scary and you have to think something bad is going on there and the differential for that is something like NEC and infarction of his viscera. Cocaine and seizure could really affect profusion.

Now going up to the vital signs the thing that really strikes me is that his hr is 200, way too fast. Either hypovolemic which is why he is mottled and poorly profusing or he is vasodialated and is in septic shock. BP awful, mean pressure of 13 way too load. Kid either needs lots of volume or dopamine in this case maybe both. FiO2 gone up as well, sats are not bad for a premie like that who has some RD so I think it is less of a respiratory issue. If sats are okay and the baby looks this bad it is probably not the lungs…Little bit of urine output…that is not as interesting to me. Of course this kid is not feeding because he is sick. Again I am going to go to the blood gas because it is going to tell me a lot and he is progressively becoming more acidodic and his PCO2 is falling so it is not a prim respiratory issue but his bicarb is precipitously falling so he has a met acidosis somewhere and the source is what we need to find out. Don’t even care about his vents at this point. Often times electrolytes at this point are not that interesting because they model moms electrolytes. Mg high and that is probably because mom got some for the seizures prophelaxius. That can give him an ileus which could explain the no bowel sounds but certainly doesn’t explain what is going on…(rest of labs)

Hematocrit at 22 is low so he is losing blood somewhere. Could have happened at birth it could be happening now. WBC count nothing interesting. Again CO2 confirms blood gas is bad. This kid is on antibiotics could still be septic but the working diagnoses now are cardiac and NEC. It is probably a cardiac issue because NEC – and I also need to think of his head. Kid who is poorly profusing, hypotensive, obviously in septic shock and he is losing blood because hematocrit…At a risk for IVH so I would get an ultrasound of his head. Cardiac issues does he have cortasion of aorta in that getting almost no distal diffusion…does he have NEC? That would be rare because he hasn’t been feed.

Doubt it is NEC and you are trying to decide b/w IVH or other cardiac issues.

In this kid I would get a head us and have cardiology come and get an echo…could also do a chest x-ray…(talking about narrowing and bad flow)

Because of the drop in hematocrit, I am thinking the IVH is probably what is going on here critical coarch is probably second on my last. That with the prematurity is probably what is going on.

What it was was liver lac…blue and tense abdomen and the hematocrit drop…

Yeah I have never seen a liver lac and it is not on my differential for everything. And if you have never see it I would doubt if anyone would pick that up from a flowsheet.

Me talking…

I was rationalizing blue tense thing with well systemic profusion is so poor with a massive intercranial hemorrhage the bowel is one of the things that takes the hit.

1. Rounds all about info collection. The intern is the one who is looking at the flowsheet the most. Critical management decisions have already been made. You put it on the note and then no one ever looks at the note again. What the nurse tells me is often more than I need to know. Looking at the baby and talking to the nurse are the first thing then the flowsheet will confirm things. So it depends, if you are rounding the flowsheet is just a source of info that if you are lucky you have
time to look at but in the acute setting where things are changing clinically the flowsheet is very important.

2. Have to know diagnoses that are out there…Do you generally have the knowledge base? I feel one of the most difficult things between transition from med student to being a physician in med school learn all diagnoses so if I am given a test and a have to choose a diagnosis from a multiple choice I have no problem with that. The hard thing is looking at a patient and thinking of the diagnosis from that patient and that is what you learn in residency is to be able to pick that diagnosis out…I found the hardest thing is I think this is this

3. 

4. Overall it is what the baby looks like and that’s the thing I have to remind myself to think of first to remember gut impression when you look at the baby. First case O2 requirement, Second case physical exam

Reliability of sources of information? Most confident in vital signs because in NICU they are for the most part are free from human error. Temp obviously is not. Everything else is elect monitor. Unless they have put a sat probe in a kids nose pretty reliable. History often is not very reliable you hope it is but often it is not.

I don’t blow off a NICU nurse, because they have so much more clinical experience at this point. Often by virtue of their training, not their intelligence, they tend not have the differential diagnosis in mind but they very well know the kid is not looking right.

5. Rely on radiology a lot. So that sometimes is a part…so for case 1 that kid is 6 hours old. I know he is going to have a chest x-ray out there. I know his chest x-ray if it has that ground glass appearance I am going to know that he has RDS.

6. I remember the mistakes I made or holy crap how could I have missed that diagnosis? The ones that I mess up (I haven’t killed anybody) the ones that I miss are the ones that I remember…The nice thing in the NICU (and this residency) that you are never quite hanging out there by yourself at this level. I know myself well enough, I feel that I have a good background but I know I need a lot to learn. So I never really do many things by myself especially with sick children. I am always running things by someone who is superior to me, upper resident or fellow. The attending is less involved in that way. Having a person to run things by and they will say oh think about this or think about that. Do they usually come to you or do you go to them? Depends how sick the kid is. Personally I like to be the first one called to them and I don’t really like people hanging around unless the kid is actively bleeding out and needs a surgeon right then and there. I like to think things through myself and how to do it and then run it by somebody before we do the plan of action. I think that is the best way to learn. NICU is the NICU and sometimes someone gets there before you.

What do you think about rounds process? I have a short attention span so in the NICU, rounds can be 3 hrs by which time you are ready to jump out the window. I think rounds are a great teaching opportunity with a good attending and I think here we are fortunate to have good attendings who actually use rounds as a teaching tool. The problem I have with rounds are patients that are not my own. I can’t focus on it and I can’t try and I can’t absorb what that patient is all about. When it is my patient and you have to explain your thought process from the night before it can be helpful.

1. Yes, on a practical basis just to collect the data for the daily note. Use the flowsheet all the time more so than any other unit. Haven’t done the PICU yet… Flowsheet on the floor are much different – less data and the data is often either questionable or not useful. In the NICU I find that there is very little irrelevant data because it is so meticulously collected. I actually think it is well organized. It is very helpful, I use it all the time. How were you trained on it? I am a little bit of an outlier here, because as a 4th year med stud I did a 1 month advanced clerkship in the NICU. So before coming I had that background. But no one taught me. I think the first day in the NICU the upper resident spent about 2½ minutes going over the flowsheet going over what it was. Really you just have to see a lot and that’s how I learned…I think that is the way it has got to be. It is an active learning process. And that is why I think they make interns round and collect data because that is the only way you are going to see patterns in flowsheet that you wouldn’t see otherwise. So much of medicine is pattern recognition.
2. First off it is a legal document. It is a record of what has happened. It is just like a transcript of a courtroom. The daily note is a joke, it may be used in a court setting. What happened why a certain decision was made. This is what shows what the baby is doing everyday. Is it a diagnosis tool, no. I think we make are diagnosis more on our clinical gut feeling and looking at the baby than anything else and this is just corroborating that.

3. …

4. If I have 8 babies to see and I have an hour to see them (7-8 min/patient). Spend 5 min on the flowsheet abstracting the data and 3 minutes looking at the baby. I think you spend more time especially when you are rounding and collecting data you spend 5 minutes, especially on the more complicated babies. I don’t know if it is how the daily progress note is set up. After glancing at the baby, again this is an ideal setting, because I don’t always do this first but I would look at the baby first and then look at the flowsheet. Not in this flowsheet here, but there is a column of interventions right next to ox sat. So I look at that for the last 24 hrs and see if anything major happened…You would be able to see the comments right there. So I look at that first and then look through vital signs. Then the physical exam, I know it is there but we don’t look at it because it is on the back and we have to flip over the sheet. Then I will look at the labs. Is there a different process when a nurse comes up to you? There is a different process. The nurse will say demonstrate more work of breathing and I will flip it over and look at blood gas. She has already told me he is breathing faster I tend to not look at the vitals…I am going to do my own exam, it is not in a very good place on the flowsheet as well...

5. The first day you come into the NICU as a resident. We have here 1 month were you are in the main NICU and 1 month in transitional nursery and you take call…The main NICU as a medical student you do not go through and in the trans nursery they give students feeders and growers but all you really need to look at what is their weight today, yesterday…A good upper level we take someone aside…It is not done in a systemized fashion. Is there room for NICU training in med school? I think for the avg medical student, they do not necessarily need to go through the NICU. Although I think it is important for them to get a sense of what the burden of prematurity…I think the time they do in the transitional nursery…there is a place for that.

6. As a resident learning from my errors of commission or omission. Trying to analyze those things that I have missed. And reading about my specific patients. Med school is totally different. You could study, memorize, crime. As a third year being glib in your presentation. I don’t think you really get grades on your decision making process…So it is a completely different process. You have to learn how to communicate...

7. …

8. Residents, I sometimes wish I had some more autonomy to make decisions. I know that is a bit of a double edge sword because my mistakes can be perpetuated and cause harm. But for me I learn by seeing a lot of patients and making decisions on them and being the exclusive decision maker in an ideal world. And that is how residency used to be where the residents called the shots and the attendings were peripherally involved at best. Med students and it depends on what school you go need to be more involved with clinically making decisions…what do you do rather than what do you know about RDS. You can know all of the pathological physiology and etiology but if you don’t know a darn bit about how to vent or manage baby it is not as helpful…in general med students need to be more involved in clinical decisions. Simulations for medical students? I think it would be valuable it just needs to be very realistic and I think they are trying to do that…

9. Some of it is years and years of pattern recognition. I even feel that I have a lot of pattern recognition that I didn’t have 6 months ago. This isn’t brain surgery/rocket science a lot of it is just being able to see where the numbers are going and how they interact. If I have had that for 8 months and am relatively facile with it and the attending has been doing it for 30 years the difference is wide. The attending doesn’t have to think about putting in all the orders, dictate those dictations, talk to the parents, and get out of here by 1:00 because I am post call. It is much easier to sit back and be able to formulate those things are at least sound more intelligent doing it then when you are a resident with so many other competing priorities. Residents we all learn it subliminally while we are doing all these other things and then as upper levels it is just kind of there. It is cool how it all happens.

10. Cases in which multiple organ systems involved and all the interactions. Kids where there are a lot of consulting services involved: surgery, neuro it sometimes hard to pull all of that together.
Cases in which the kid comes to you from a transport and has diagnosis x and then someone else comes to you and says no this is the diagnosis. Those cases are hard. A lot of it comes down to experience and having that baby there and decompensating. Being the person that provides the intervention. Just the experience. You could probably teach anybody with a reasonable IQ do to these things even if they were not medically trained. You see this in nurse practitioners who don’t have med school training…They do all of this stuff. You could probably train anybody to do this you just need to give them enough time.

11. Medical school here and residency here. Main NICU flowsheet is easiest to read and maybe that is because I have the most experience with them. The transitional flowsheet I do not like at all the data is more compressed, there is not enough space to write so it is often illegible as far as comments, and it doesn’t give as much info. The floor flowsheet are essentially worthless other than to get vital signs.
## Appendix G: Plan of Study

### Project Timeline

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