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MAP OF THE CHILD

In his first book, pediatrician DARSHAK SANGHAVI takes readers on a gripping, emotional tour of children's bodies—from their bones to their brains. Using a collection of stories about his young patients and their families,

Dr. Sanghavi applies a poet's sensibility to the workings of each organ, explaining the science, the history and the medicine behind the treatment of such maladies as leukemia, asthma and heart defects. In this excerpt, Dr. Sanghavi describes the birth of a premature boy, born before his lungs were fully formed, and his struggle to survive.

The first time I saw a live birth in medical school, I earned an amused smile from the supervising resident when tears rolled down my face. Childbirth never ceased to amaze me, and my eyes would frequently mist, a condition I handled by blinking rapidly. This time I wouldn't have time to hide my tears. Justine Flax, 32 years old, was about to give birth to twins, the product of test-tube fertilization, at the Brigham and Women's Hospital in Boston. The trouble was, they were being born about two months too early.

Justine had named them already; the firstborn would be Adam, and he would be mine to resuscitate if necessary.

Before getting any further information, I opened up my bright yellow tackle box that held everything needed for resuscitation, including the proper-size tubes to be placed in premature infants' windpipes if necessary. Obstetricians are notorious for suddenly delivering a baby when the occasion requires it; the fastest cesarean delivery I ever saw was accomplished in less than 60 seconds from the woman's entrance into the operating room. I took



particular pride in organizing my tackle box. From it, I extracted a small 2.5 French tube, the smallest in the box.

The tube was critical because Adam's tiny lungs weren't ready to breathe at this stage. Without oxygen our cells become primitive again, like the cells of billions of years ago, capable only of paltry metabolic feats. When muscles burn after vigorous activity, the pain means they were briefly oxygen-starved and therefore accumulated lactic acid. Muscles recover quickly, since the acid is neutralized once activity ends. Brain tissue, though, is not so forgiving and can withstand oxygen deprivation only for a few minutes before suffering permanent damage. This was the problem Adam Flax was about to face.

Adam's mother had premature labor, meaning that her uterus began contractions far too early. Since the lungs are the critical determinant of when a baby is ready to be born, obstetricians are frequently hesitant to deliver a baby two months ahead of time.

Justine's doctors had tried to persuade her uterus to relax, a process of negotiation first begun with a shot of terbutaline under the skin, which sometimes places the uterus back into hibernation until the nine months are up. That didn't work. Soon afterward, both magnesium and terbutaline were administered intravenously, also without appreciable effect. It appeared that no amount of chemical persuasion was going to work on Justine's uterus.

Then there was another complication. Over the past two hours, monitors placed on Justine's abdomen had indicated that the twins' heart rates were periodically decreasing, a sign that could mean worsening infection or a lack of oxygen. The children were no longer safe in Justine's uterus. Whereas previously the obstetricians had tried to postpone delivery as long as possible, it now became imperative to deliver the babies quickly. The fastest way to get them out was by performing a cesarean section.

I couldn't see Justine's face when I entered the suite; a sterile surgical partition divided her neck from her body, obscuring us from each other's view. Her husband, an Irish-American man of about 30 named Paul, sat on a stool at the head of the operating table and held Justine's hand, which extended into my field of view. I walked a few paces over to gain some connection to the woman whose large abdomen was lit majestically in the center of the suite by high-intensity lamps. Paul was whispering continuously into his wife's ear, as tears rolled down her face. Justine lay on her back on a table in the middle of the operating room, saying over and over: "They're not ready. They're not ready. I'm not ready." Monitors at the

head of the table indicated her heart rate, respiratory rate and blood-oxygen content. Numb from a spinal anesthesia, Justine's belly was painted dark brown with an antiseptic. A long horizontal incision had been made.

I walked again to the warming table where Adam would be brought and returned to my tackle box. We were ready to reel Adam into the world of the living. Mary, the triage nurse in the newborn intensive care unit (NICU), hooked up the oxygen supply to the wall source, obtained warming blankets and



set the warming table temperature high, slightly over 100 degrees. One of the biggest problems with newborns is that they can cool down rapidly since they are born wet. "Got the pipe?" she asked, referring to the endotracheal tube I had picked out. "Yup," I answered. "You better get an extra one, one size up," she advised smoothly, her voice just above the hiss of oxygen emanating from the tubes she had connected.

The obstetricians were still a few moments away from opening the uterus and delivering Adam, so I introduced myself to Paul and Justine. "Hi, I'm Dr. Sanghavi. We're going to take care of your little ones. Since they're being born early," I cautioned, "they probably won't be able to breathe well on their own, and we'll have to put a tube down their throats and into their lungs to help them breathe. You'll be able to see them and just maybe touch them, and then we'll have to take them upstairs." Paul swallowed, looked blankly at me and nodded. Justine didn't say anything. I opened my mouth to offer additional words of encouragement, but the obstetricians had begun to incise the uterus. I scooted back to the warmer and joined Mary.

Suddenly, clear fluid fountained from Justine's abdomen. The obstetricians had broken her water and suctioned the fluid with vacuum-powered hoses that extended to receptacles

several yards away. The hoses writhed as fluid rushed through them. I could see Adam's head, the size of a large orange, poking through the uterus, his body still hidden. Quickly, the obstetrician harvested the child, literally reaping him from the uterus by pulling him out by his head. With another rapid movement, he severed the umbilical cord, and in that motion the obstetrician's responsibility for Adam's life ended.

In the same motion, my responsibility began. Like a quarterback, the obstetrician handed off Adam to the scrub nurse, who ran the newborn over to the warming table and deposited him in front of me. Touchdown, I thought. But Adam, covered by blood and amniotic fluid, didn't move at all, didn't breathe. He just lay there, blue as the sea. "It's a boy!" I heard one of the nurses say to Justine.

Usually, babies cry when they're delivered; the first breath heralds a stunning transformation in the lungs, which are full of amniotic fluid in utero. A baby doesn't need to breathe in the womb, since the mother's blood carries oxygen through the placenta, a sort of life-support organ attached to the uterus.

The baby's cry is really a first breath, a motion that unfurls the newborn lungs like sails. Billowing in the chest, the lungs suddenly begin to receive blood from the heart (which previously bypassed the lungs through a special blood vessel). At the warming table a pediatrician sees a sudden ripening of the baby; the brilliant blue of the baby's skin turns to a pink glow within seconds. "He's a rose," Mary would purr contentedly when we presided over a healthy delivery.

But Mary didn't say anything when Adam came to us. She roughly dried him with the towels, and I rubbed his back, trying to stimulate an adrenaline surge, since cesarean deliveries don't produce as much squeezing and stress to provoke adrenaline as do vaginal deliveries. But ten seconds passed, and Adam just lay there on his back, not breathing.

"Now," insisted Sanjiv. Adam was lying on his back, with his head tilted toward me. I took the laryngoscope, a blunt metal blade with a lighted bulb on its tip, inserted it deep into Adam's mouth and pulled toward the ceiling. Holding the laryngoscope in my left hand, I took the 2.5 French tube in my right and inserted it into Adam's mouth. I worked the tip toward the epiglottis and pushed the tube into the opening just below it. Two sail-like folds became visible in the opening; they were the vocal cords. I felt Sanjiv move forward impatiently, ready to take over from me. Though my hands were shaking a bit, I finally worked the tip of the tube past the cords. It all took about six seconds. Adam was tubed. I removed the laryngoscope, and Mary took over. Though the room was cold, I reached up to wipe sweat from my forehead.

Mary attached a rubber bag to the end of the tube. This bag in turn is connected by a second tube to an oxygen pump. The rubber bag served as Adam's lungs. Mary squeezed and released the bag vigorously about once every two seconds, forcing oxygen from the bag into Adam. At the same time, Sanjiv listened to Adam's heart and lungs with his stethoscope. The biggest mistake I could have made was to insert the tube into the esophagus instead of the trachea, which would simply lead to oxygen being pumped into Adam's belly. But Sanjiv gave me a thumbs-up; he heard air move in the lungs.

"Heart rate's up," he called, meaning that Adam's heart was beating faster, a sign that oxygen was reaching his body. "And there's condensation in the tube. But I don't hear air on the left side of the chest."

The trachea branches into two segments, or mainstem bronchi: one that enters the right lung and one that enters the left. Frequently, a small child who chokes on a peanut or piece of popcorn—foods not recommended by the American

USUALLY, BABIES CRY WHEN THEY'RE DELIVERED; THE FIRST BREATH HERALDS A STUNNING TRANSFORMATION IN THE LUNGS.

"Tube him," said a voice behind me.

It was Sanjiv Khanna, the supervising neonatologist, who was watching over my shoulder. Sanjiv knew that time was critical to the newborn infant; every second we waited was another second that Adam's brain was starving for oxygen. Delay could mean a lifetime of cerebral palsy or brain damage. Adam had failed to breathe on his own, and it was our turn to take over.

Intubation, or the placement of a breathing tube into the windpipe, is the first step in a critically ill newborn's resuscitation. It's a very difficult procedure. Everything about a premature baby is small, including the windpipe, and getting the tube in the right place takes practice. It's something like defusing a bomb; there's limited time to succeed, and if you fail, someone dies.

Academy of Pediatrics for any toddler—has lodged the item in the right mainstem bronchus since it has a more favorable angle of entry from the trachea. Similarly, I had inserted the tube too far into Adam's lungs, directly into his right mainstem. That's why Sanjiv couldn't hear any air in Adam's left lung; only the right was getting oxygen.

"Pull back the tube," Sanjiv said to me, in the somewhat understated but urgent tone of a flight instructor telling a novice pilot to "pull back on the stick" to avoid a crash landing. I retracted the tube about one centimeter so that both mainstems received oxygen, and Sanjiv listened again to Adam's chest and smiled. "Equal breath sounds," he said.

Mary beamed as Adam's skin turned pink. "He's a rose," she concluded.

The baby's father accompanied Mary and me from the

operating room to the NICU. In the delivery room, a second resident had managed Adam's twin, a little girl named Evelyn. In the NICU, she would be on a warmer next to him. On the elevator, as Mary squeezed the bag giving oxygen and life to Adam, Paul told me in an emotional voice about how hard he and Justine had tried for children, and about visits to various fertility experts. To have children was the most powerful longing he had ever felt, Paul said. Justine had gotten pregnant by artificial insemination after four years of attempts. "It's a goddamn miracle," he said hoarsely, gazing at his child.

We saw things so differently, I thought. I was fixated on the warmer that kept Adam's body temperature up, the oxygen bag that inflated his lungs and the tones of his heart through my stethoscope. Paul didn't see a critically ill child; he looked at a heaven-sent gift, a perfect newborn son whom he would one day teach to eat with a spoon, to throw a ball and to tie a shoe.

I reached out a hand to Paul's shoulder, which trembled with emotion. His eyes met mine, and we didn't need to say anything.

Adam was brought to the NICU and "booked." Electrical wires were taped to his chest to follow his heart rate and breathing, his breathing tube was hooked to a mechanical ventilator, and intravenous catheters were inserted into his veins. Instead of showing clear, dark lungs, a chest X-ray showed them filled with fine, dusty shadows. This was the hallmark of premature lungs, and the dusty shadows were going to be a problem. Evelyn, too, had shadows on her X-ray.

The shadows indicated the presence of thousands of small, balloonlike areas called alveoli. In the lungs, the mainstem bronchi subdivide into smaller and smaller branches, which end in the alveoli, the cul-de-sacs of the pulmonary neighborhood. In healthy full-term infants the alveoli are filled with air, but in Adam's and Evelyn's lungs they remained collapsed, giving their X-rays a hazy appearance.

High pressures are required to pop open the alveoli for the first time. Once open, they'd require far less effort to stay inflated. Since most of Adam's alveoli were closed, we also were forced to pump high concentrations of oxygen into his lungs to keep him from suffocating. But oxygen in pure form at high pressure is a surprisingly deadly substance. The same attribute that makes oxygen a key biological necessity—its startling ability to react with organic

compounds—allows it to harm healthy areas of the lungs if breathed for too long at the concentrations we were using. Adam's appetite for oxygen would be a self-destructive glut-tony unless we could inflate his lungs more easily.

Adam was one of about 20,000 to 30,000 infants who are born yearly in the United States with immature lungs, or "respiratory distress syndrome." Until 1959, no one knew why these newborns couldn't breathe properly, and many of them died. Mary Ellen Avery, a pediatrician at Children's Hospital in Boston, discovered that year that many premature babies lack a key compound called surfactant, a slippery, soapy substance that makes it easier for the lungs to inflate. No one was able to use this knowledge to help newborns until 1972, when G.C. Liggins and R.N. Howie discovered that steroids injected into mothers undergoing premature labor caused their unborn fetuses to produce surfactant. Unfortunately, this wasn't a perfect solution; despite receiving steroids, many mothers still delivered newborns with respiratory distress syndrome. Adam was one of them.

In 1980, a group of Japanese pediatricians led by T. Fujiwara successfully took surfactant purified from cow lungs and administered it to a premature baby. Since then, surfactant (or "surf," as we called it in the NICU) has become a key reason that almost all premature babies of Adam's gestational age are able to survive.

Dottie Upshaw, the respiratory therapist, flicked back her short red hair. "Well, are we gonna surf, or what?" she drawled, as she adjusted Adam's ventilator. "Let's do it," I agreed.

We approached Adam's unit and watched the ventilator give him breaths, at pressures almost twice what is required for an adult. Remarkably, Adam's chest barely expanded; listening to his chest with my stethoscope, I heard the crackling, popping noises of immature lungs.

Dottie emptied the syringe of surfactant directly into Adam's breathing tube. Almost immediately, Adam's chest began rising like a loaf of bread. The surfactant invaded Adam's collapsed alveoli, which began popping open like cell doors in a jailbreak. Adam's lungs were inflating, free at last. The following day, the ventilator was removed, and Adam took his first breath by himself. He even yawned. ■



HE DIDN'T SEE A
CRITICALLY ILL
CHILD; HE SAW A
PERFECT NEWBORN.