Surgeons at Le Bonheur Children’s Hospital successfully separated conjoined twins, Joshua and Jacob Spates, on Monday, Aug. 29. The twins were joined at the lumbosacral spine and shared a rectum, muscle and nerves. The 13-hour surgery featured a 35-member team and four surgical specialties — general surgery, neurosurgery, orthopaedic surgery and plastic surgery.

The first of the twins, Joshua, went home on Sept. 20, 23 days after separation from his brother, Jacob. Jacob remains at Le Bonheur awaiting repair of a double outlet right ventricular heart defect.

Born via Caesarian section on Jan. 24, 2011, the babies were pygopagus twins, joined back to back at the pelvis and lower spine. Each had separate hearts, heads and limbs. Pygopagus represents 15 percent of conjoined twins.

Diagnosis and Prenatal Care, Le Bonheur Fetal Center

The Spates twins were diagnosed prenatally via ultrasound at 25 weeks gestation. Their mother, Adrienne Spates, was referred to Le Bonheur’s Fetal Center in November 2011. Spates and her boys were followed by Fetal Center Medical Director Giancarlo Mari, MD, who coordinated care with various subspecialists over the duration of the pregnancy.

Fetal ultrasound, with three-dimensional software, and fetal MRI — coordinated by the Department of Radiology — were used to help diagnose the twins in utero.

The boys were transferred to Le Bonheur Children’s Hospital seven hours after Mari delivered them via Caesarean section on Jan. 24.

Baby A, or Joshua, was diagnosed with complications of situs inversus totalis, calcifications in the spleen and a heart defect. Baby B, or Jacob, was diagnosed with Dandy-Walker syndrome, hydrocephalus, two-vessel umbilical cord and a heart defect.

continued on page 2
Growth and Surgery Preparation,
Le Bonheur Neonatal Intensive Care Unit

Two days after birth, pediatric surgeons performed a colostomy and inserted a gastrostomy tube to assist with nutrition and waste elimination. The twins spent the next seven months in Le Bonheur’s Neonatal Intensive Care Unit, where they grew from 2.92 kilograms to 13.53 kilograms. Ongoing therapy and treatment from a multidisciplinary team of subspecialists allowed them to grow and develop until their surgical separation.

Meanwhile, surgeons used the time to plan for separation of the boys, largely relying on Radiology’s 320-slice CT Scan and MRI technology to understand their connection. The hospital’s 320-slice CT Scanner provided software that helped physicians see where the vertebral bodies were fused, providing high-resolution depiction of the complex anatomy. From the neurosurgical aspect, the MRI showed fusion of the spinal cord, the relationship of the nerves off the fused cord and relationship of the vertebral bodies to the cord.

On July 26, Plastic Surgeon Robert Wallace, MD, implanted tissue expanders to prepare for the separation. Those expanders were injected with saline six subsequent times prior to separation.

Separation Surgery

The Spates twins were separated on Aug. 29, 2011, in a 13-hour surgery where surgeons separated the spinal column, spinal cord and muscles and completed gastrointestinal repairs. The surgical team included 35 members, including surgeons, anesthesiologists, certified registered nurse anesthetists, surgical technicians, registered nurses and a radiological technician.

Each twin was assigned a surgical team for each specialty – general surgery, neurosurgery, orthopaedics and plastic surgery. An anesthesiologist and certified nurse anesthetist were also assigned to each twin. The boys were separated a little more than 10 hours into the surgery and then moved to separate operating rooms.

Future Prognosis

Baby A (Joshua) has since gone home. Baby B (Jacob) remains at Le Bonheur, awaiting surgery to repair his double outlet right ventricular heart defect. Both have ostomies and will be followed long term in Le Bonheur’s Spina Bifida Clinic.

Joshua is expected to function like a child with spina bifida involving a lower lumbar spinal cord and should be able to walk with braces, said Orthopaedic Surgeon William Warner, MD. Warner hopes Jacob will be able to walk with braces as well.

About Conjoined Twins in Memphis

- Six documented conjoined twins in Memphis history.
- Last separated case occurred in 1970s.
- Previous separations performed in Memphis resulted in the death of at least one of the twins.

Surgical Timeline: Separation of Conjoined Twins Joshua and Jacob Spates

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:40 a.m. – 12:10 p.m.</td>
<td>General surgery team begins preparation for separating the colon</td>
</tr>
<tr>
<td>12:41 – 1:23 p.m.</td>
<td>Babies are flipped from side to side</td>
</tr>
<tr>
<td>1:27 – 2 p.m.</td>
<td>Plastic surgery team removes both tissue expanders and elevates the second skin flap on Joshua’s leg</td>
</tr>
<tr>
<td>1:32 – 3:41 p.m.</td>
<td>Neurosurgery and orthopaedics teams access the conjoined spinal canal and separate the bony elements of the spine and spinal column</td>
</tr>
<tr>
<td>3:42 – 5:22 p.m.</td>
<td>General surgery completes the colon separation and prepares Joshua to be moved to Operating Room 6</td>
</tr>
<tr>
<td>5:02 p.m.</td>
<td>Joshua is moved to Operating Room 6</td>
</tr>
</tbody>
</table>
Diagnostic images, radiologists give surgeons a leg up in planning

From the moment the Spates twins were diagnosed as conjoined, diagnostic imaging became a key tool for their care. Physicians relied on ultrasound, MRI and CT scans, plain film and fluoroscopy and an experienced team of radiologists to develop a plan to separate the boys and diagnose their problems.

Prenatally, fetal ultrasound with 3D software and fetal MRI confirmed the fusion of the twins’ vertebral column and soft tissue of posterior back area, along with showing other congenital defects for each fetus.

Once the boys were born, MRI imaging and 320-slice CT scans were used to show the fusion of the spinal cord and vertebral bodies. The boys received both MR and CT scans in July – about six weeks before separation — to help surgeons plan procedures.

Pre-operative, 320-slice CT scans allowed for accurate 3D computer reconstruction of vertebral bodies. Orthopaedic surgeons used the CT scans to define the complex bony connections between the twins’ pelvis and shared sacrum – and found no surprises during the actual surgery. The additional information enabled surgeons to move quickly through the orthopaedic portion of the separation.

MR scans clearly showed fusion of the cord, the relationship of nerves off the fused cord and relationship of the vertebral bodies to the cord.

“Neuroradiologist Asim Choudhri, MD, created some beautiful spinal cord tractography on the case showing the crossing nerve fibers,” said Rick Boop, MD, chief of Neurosurgery at Le Bonheur Children’s. “It helped us tell mom what to expect neurologically.”

Le Bonheur Chief of Radiology Harris Cohen, MD, credits both the technology and experienced Maternal Fetal Medicine and Radiology clinical images with helping plan for the surgery.

“Our team of pediatric radiologists have varying levels of broad and subspecialty experience. They are able to use the great technological tools and software programs to get the most from our images,” Cohen said. “I can’t emphasize enough how our experience, ability to think outside the box and willingness to consult with each other helps put things together for best patient care and diagnosis.”

A 3D reconstruction of 320-slice CT scan shows how vertebrae for the Spates twins are conjoined at 6 months of age.

A fetal MRI before they were born shows the Spates twins and where they are conjoined.

A 3D reconstruction of 320-slice CT scan shows how vertebrae for the Spates twins are conjoined at 6 months of age.

MR images taken of Joshua, left, and Jacob, right, show where the boys were conjoined, in the lower sacral spine. Radiologists used fetal ultrasound and fetal MRI to learn more about them before they were born. After birth, 3D CT scans and MRI technology helped further characterize their conditions.

Operating Room 7 Timeline

5:33 – 5:50 p.m. Team prepares and re-drapes Jacob to maintain the sterile field
5:54 – 6 p.m. Jacob’s surgery resumes; neurosurgery and orthopaedic teams repair the myelomeningocele and close Jacob’s back and spine
6 – 7:15 p.m. General surgery team repairs Jacob’s anus
7:17 – 8:15 p.m. Plastic surgery team advances expanded skin and rotates flap to cover vital structures

Operating Room 6 Timeline

5:40 – 5:45 p.m. Team prepares and re-drapes Joshua to maintain sterile field
5:47 – 6:38 p.m. Joshua’s surgery resumes; neurosurgery and orthopaedic teams repair the myelomeningocele and close Joshua’s back and spine
6:38 – 6:52 p.m. General surgery team repairs Joshua’s anus
6:54 – 8:02 p.m. Plastic surgery team advances expanded skin and rotates flap to cover vital structures
8:16 p.m. Both babies are moved to the Pediatric Intensive Care Unit
THE SURGICAL TEAM

The separation of conjoined twins Joshua and Jacob Spates was the most complex in Le Bonheur history. The 13-hour surgery required multiple pediatric surgical specialties, including anesthesia, general surgery, neurosurgery, orthopaedic surgery, plastic surgery, and radiology. Each team member was assigned to a twin and specialty throughout the procedure. The 35-member pediatric surgical team included:

- 6 general surgeons
- 4 orthopaedic surgeons
- 4 neurosurgeons
- 3 plastic surgeons
- 2 anesthesiologists
- 2 certified registered nurse anesthetists
- 5 surgical technicians
- 7 registered nurses
- 1 radiological technician
- 1 sterile processing department organizer

**The Surgical Team Members**

- **Jim Beaty, MD**
  - Role: Orthopaedic surgeon
  - Orthopaedic surgeon, Campbell Clinic Orthopaedics and Le Bonheur Children's Hospital; Director of the Department of Orthopaedic Surgery, The University of Tennessee Health Science Center, (UTHSC)

- **Max Langham, MD**
  - Role: Team leader, lead general surgeon, leader of planning and preparation efforts
  - Medical director of Pediatric Surgery, Le Bonheur Children's Hospital; Chief of Pediatric Surgery and director of the Residency Program, UTHSC

- **Rick Boop, MD**
  - Role: Neurosurgeon
  - Chief of Pediatric Neurosurgery, Le Bonheur Children's Hospital; Professor and J.T. Robertson Chairman, Department of Neurosurgery, UTHSC and St. Jude Children's Research Hospital; Neurosurgeon, Semmes-Murphey Neurologic and Spine Institute

- **Frida Hammons, RN, PCC**
  - Role: Operating Room Team Member
  - Operating Room Team, Trauma and Orthopaedics

- **Giancarlo Mari, MD**
  - Role: Prenatal care and obstetrics team leader
  - Medical director of Pediatric Surgery, Le Bonheur Children's Hospital; Chief of Pediatric Surgery and director of the Residency Program, UTHSC

- **Nikki Freeman, RN**
  - Role: Circulator
  - Circulator, Operating Room Team

- **Asim F. Choudhri, MD**
  - Role: Neuroradiologist
  - Neuroradiologist, Le Bonheur Children's Hospital; Assistant Professor of Radiology and Neurosurgery, UTHSC

- **Harris L. Cohen, MD**
  - Role: Radiologist
  - Medical director of Radiology, Le Bonheur Children's Hospital; Professor of Radiology, Pediatrics and Obstetrics, and Gynecology, UTHSC; Chairman of Radiology, UTHSC

- **B. Rao Paidipalli, MD**
  - Role: Anesthesiologist
  - Operating Room Patient Flow director; Le Bonheur Children's Hospital; Assistant professor for the Department of Anesthesiology, UTHSC

- **Ramasesubreddy Dhanireddy, MD**
  - Role: Neonatologist
  - Medical director of Neonatology, Le Bonheur Children's Hospital; Chief of Neonatology, UTHSC

- **Regan Williams, MD, Scott Wate, MD, Thomas Sims, MD, Joel Saltzman, MD, Eunice Huang, MD, Marilyn Robinson, MD, Derek Kelly, MD, Max Langham, MD, Rick Boop, MD, Harris L. Cohen, MD, Asim F. Choudhri, MD, B. Rao Paidipalli, MD, Ramasesubreddy Dhanireddy, MD, Marilyn Robinson, MD, Derek Kelly, MD, Thomas Sims, MD, Joel Saltzman, MD, Eunice Huang, MD,**

- **Jeff Sawyer, MD**
  - Role: Orthopaedic surgeon
  - Orthopaedic surgeon, Campbell Clinic Orthopaedics and Le Bonheur Children's Hospital; Director of the Department of Orthopaedic Surgery, UTHSC

- **Gordon Corder, CRNA**
  - Role: Anesthetists
  - Certified Registered Nurse Anesthetists

- **Robert Wallace, MD**
  - Role: Lead plastic surgeon, insertion and removal of skin expanders, incision design
  - Program director for the Craniofacial and Plastic Pediatric Surgery fellowship at Le Bonheur Children's Hospital; Professor and chairman of the Department of Plastic Surgery, UTHSC; Chief of Plastic Surgery, St. Jude Children's Research Hospital

- **William Warner, MD**
  - Role: Lead orthopaedic surgeon, spinal column separation
  - Orthopaedic surgeon, Campbell Clinic Orthopaedics and Le Bonheur Children's Hospital; Professor, department of Orthopaedic Surgery, UTHSC; Chief of Orthopaedics, St. Jude Children's Research Hospital; Chief of Orthopaedics, Mississippi Children's Services

- **Mark Williams, MD, FAAP, FACS**
  - Role: Urologist
  - Associate chief of staff-elect, Le Bonheur Children's Hospital; Chief of Urology, Le Bonheur Children's Hospital and St. Jude Children's Research Hospital; Assistant professor, chief of Pediatric Urology and program director for the Pediatric Urology Fellowship Program, UTHSC

**Other Surgical Team Members**

- **Surgical Fellows**
  - Siddha Abraham, MD, Plastic Surgery
  - billboard Burke, MD, Neurorsurgery
  - Agnes "Bess" Glorie, MD, Plastic Surgery
  - Jimmy Green, MD, General Surgery
  - Jeremy Hash, MD, Orthopaedics

- **Radiographer**
  - Brenda Bryan, OR Biomed

- **Equipment, In-room Camera Department**
  - Joyce Mitchell, ST