One of the most important medical-technological achievements of the 20th century was the development of minimally invasive surgical techniques in adult and pediatric patients. Undoubtedly, laparoscopic and thoracoscopic surgery has had a major impact in the management of many pediatric illnesses.

Laparoscopic surgery has proven safe, efficient, technically feasible and well-tolerated in infants, young children and teenagers. Its main advantages relate to reduced hospital stay, decreased hospital charges, decreased pain, early return to normal activities and better cosmetic results when compared to open (conventional) procedures. For the patient and his/her family, this translates to less pain and discomfort and quick return to activities of daily life—school, sports and play.
Brief History of Laparoscopic Surgery

For almost 200 years, physicians have struggled to develop techniques of minimal access surgery. Unfortunately, the equipment, optics, technology and instrumentation of earlier times were archaic. Thus the field of minimally invasive surgery for pediatric patients didn’t truly develop until approximately 10 years ago. Moreover, it wasn’t until 7 years ago that advanced laparoscopic surgical techniques were introduced to pediatric surgery.

The development of the fiberoptic transmission of light in 1928, the rod-shaped lens of Hopkins in the early ’60s, and video technology during the late ’70s, renewed interest in accessing the body cavities by minimally invasive technique using the endoscopic technology. Our fellow physicians, the gynecologists, dominated this field for many years and assisted general surgeons in developing the technique for laparoscopic appendectomy and cholecystectomy. In the late 1980s, laparoscopy was still mainly a gynecologist’s tool, so the gynecologists were the first to be offered the modern age “electronic laparoscopes.”

The revolution that introduced modern age laparoscopic surgery to general surgery occurred in France in 1987, in the province of Lyon, when Phillipe Mouret successfully removed the woman’s gallbladder using laparoscopic technique. Dr. Mouret, a general surgeon who shared his surgical practice with a gynecologist and thus had access to both laparoscopic equipment and, importantly, to patients requiring laparoscopy, wrote in 1994: “I could not understand why surgeons were not using laparoscopy but still laparotomy; the patients clearly preferred laparoscopy.” The first paper published in the English medical literature was in 1990 by French surgeon, Francois Dubois, titled: “Coelioscopic Cholecystectomy” (Annals of Surgery, January 1990). Since that time, laparoscopic general surgery has experienced exponential growth, driven by a combination of patient demand and an increasing interest of a large number of surgeons around the American and European continents. Within only two years (1988-1990), laparoscopic cholecystectomy became so popular that most patients demanded to have their gallbladders removed using minimally invasive technique. From that point on, new techniques were quickly introduced and the indications for laparoscopic surgery expanded to almost every organ in the abdomen. Soon thereafter, thoracoscopic surgery emerged as a new field with a tremendous impact in lung and cardiac surgery.
Pediatric Laparoscopy

Pediatric laparoscopy grew very slowly and lagged behind general and gynecologic surgery. In 1993, it was estimated that less than 10 percent of pediatric surgeons were beginning to explore the possibility of performing laparoscopic procedures in children. The main reason for that was the surgeons’ lack of experience with laparoscopic techniques, limited number of patients in which the most common procedure (laparoscopic cholecystectomy) could be used, and an overall resistance to change. In the early 1990s, many pediatric surgeons argued that children usually did so well with open surgery and that most procedures were of short duration when done open. Also adding to this resistance to change was the size of the optics and instruments, which were not tailored to the small bodies of infants and children, making laparoscopic exploration somewhat cumbersome and difficult. Small scopes (5 mm) were not yet available. Credentialing and training were very tedious, costly, poorly regulated and time consuming. This led to the labeling of laparoscopic pediatric surgery as “Nintendo surgery” or “making a ship in a bottle.”

One must remember that the scientific concept supportive of minimally invasive surgery is that the size of the wound has a direct correlation to the metabolic and endocrine response to surgical trauma. The greater the cutting of fascia, muscle and visera, the higher the humoral and catabolic response of the body to surgical insult. In addition, minimal access surgery results in less post-operative pain, decreased recovery time and improved cosmetic results. Thus infants and children, just like adult patients, would benefit from less invasive surgery. Fortunately for pediatric patients, the persistence of a few pediatric surgeons interested in laparoscopic surgery led to the development of better instruments with technical advances designed to meet the needs of our small patients. Since 1995, the use of advanced pediatric laparoscopic surgical techniques has been applied to an increasing number of patients with an exponential increase in scientific publications that supported the use of laparoscopic and thoracoscopic surgery for pediatric illnesses. It is safe to say that children of the 21st century will now be able to fully benefit from modern robotic and minimally invasive surgery.
The growth of the field is illustrated by the development of the International Pediatric Endosurgery Group (founded in 1995) and the first publication, also in 1995 of a journal dedicated exclusively to pediatric minimally invasive surgery (Journal of Pediatric Endosurgery & Innovative Techniques). Indications for either diagnostic or therapeutic laparoscopy and thoracoscopy have grown. The following is a list of minimally invasive procedures available for pediatric patients:

### Thoracoscopic
- Creation of a pericardial window
- Decortications for empyema
- Excision-plation of bulla (for spontaneous pneumothorax)
- Lobectomy or wedge resection
- Lung biopsy and wedge resection
- Mediastinal exploration
- Minimally invasive repair of pectus excavatum

### Laparoscopic
- Appendectomy
- Adrenalectomy
- Bile duct exploration
- Bowel resection
- Cholecystectomy
- Colectomy (for Crohn's disease, ulcerative colitis, and familial polyposis)
- Exploration for unexplained tachycardia
- Exploration for hernias
- Enterolysis (for intussusception)
- Gastrotomy
- Heller myotomy (for treatment of achalasia)
- Jejunostomy
- Liver biopsy
- Lymphadenectomy
-Medioplasty and excisional hernias
- Nephrectomy
- Nissen fundoplication

It is important to emphasize that not all pediatric patients are candidates for minimally invasive surgery. Some contraindications for performing laparoscopy are: history of severe cardiopulmonary conditions, uncorrectable coagulopathy, severe prematurity, distended abdomen (ileus), and multiple previous abdominal operations.
What is Robotic Minimally Invasive Surgery?

As previously mentioned, one of the most important medical-technology achievements of the 20th century has been the development of optical and surgical instruments that set the stage for the advancement of minimally invasive surgery. The 21st century is witnessing a revolution in the field of surgery with the introduction of the da Vinci Surgical System. The fourth generation and most advanced robotic system is now being used at the Medical University of South Carolina. The system was introduced to MUSC in May of 2008 by Dr. Hebra, Chief of the Division of Pediatric Surgery, who has had more than 5 years of robotic surgical experience.

How did robotic surgery start?

The use of robotic surgical techniques originated from a U.S. Defense Department project focused on remote field management of wounded soldiers. The U.S. military was interested in developing a system of operating on patients via a computerized, robotic interface. Such a system would allow for remote surgery, in which the operating surgeon would be located at a different site from where the operation was being performed. The initial research work that gave birth to the robotic system was a result of a combined effort by the Stanford Research Institute, IBM Corporation and the Massachusetts Institute of Technology. Despite the successful development of a computerized, robotic surgical system, the research sponsored by the Defense Department was abandoned but, fortunately, it was quickly adapted for clinical use by Intuitive Surgical Corporation (Sunnyvale, California). The system was named da Vinci and introduced to clinical use in 1997. To date, the da Vinci system is the only surgical robot for sale in the United States with FDA clearance for performing surgery.

Currently, without computer-assisted technology, experts agree, minimally invasive laparoscopic and thoracoscopic surgery would have limited applications. The use of a robotic system with computer interface and improved imaging allows surgeons to perform more complex operations that could not be accomplished with ease using conventional laparoscopic/thoracoscopic techniques. It is likely that technological advances will continue to expand the field of robotic surgery.
How Does the da Vinci Robot Work?

The da Vinci system is a computerized four-arm robot entirely controlled by the operating surgeon from a separate console that functions as the command center for the machine. The robot arms are capable of holding and manipulating the laparoscopic camera, fine surgical instruments and various sources of energy (electrocautery or harmonic scalpel) during the operation. It is not a robot in the sense of one you would imagine on an automotive industry assembly line but one that integrates the latest advancements in robotics, computer-enhanced technology and the surgeon’s skill. It allows the surgeon to perform delicate and complex laparoscopic or thoracoscopic procedures with great precision and superb visualization.

The system consists of several components: a surgeon console, patient side-cart, instruments and image processing equipment. The robot cannot perform any movement or procedure without the surgeon’s control. The operating surgeon has the ability to control each one of the robot’s four arms throughout the operation. Fine and delicate movements performed by the surgeon via the robotic arms and instruments are fully visualized in true 3-D, allowing the surgeon to perform as if he or she were inside the body. The system allows for highly precise movements and maneuvers that frequently are superior to what the human hand can accomplish during open surgery.
Who’s Actually Performing the Surgery?

The da Vinci Surgical System does not replace the surgeon, but rather adds to existing technology in minimally invasive surgery to improve the surgeon’s capabilities. The operations are performed entirely under the control of the pediatric surgeon. The robot will allow the surgeon to be more precise in performing certain procedures using laparoscopic and thoracoscopic technique. It responds to the surgeon's movements in real-time. The robot cannot be programmed, nor can it make decisions on its own to move in any way or perform any type of surgical maneuver without the surgeon’s input. The robot simply moves special instruments via the robotic arms that mimic the surgeon’s movements on a smaller and finer scale. Because of its four-arm configuration, it will allow the surgeon to work as if he or she had four arms and hands. The system is designed so the surgeon can be in complete control of the robot and the procedure at all times.

What are the Benefits of Using the Robotic Surgical System?

Some of the major benefits experienced by surgeons using the da Vinci Surgical System over traditional open methods of surgery have been greater surgical precision, increased range of motion (particularly for technically challenging operations), increased dexterity, and enhanced 3-D high-definition visualization of the surgical field. Such qualities have allowed surgeons to perform complex operations that could not be easily accomplished using conventional laparoscopic or thoracoscopic techniques. With more precise control in the surgical field, complications can be decreased and outcomes are optimized.

Advantages of the da Vinci system in surgical procedures for children:

- Availability of small (5 mm) instruments for infants and children
- Ability to provide the surgeon with 4 operating arms
- Easier manipulation in small and confined body cavities
- Greater dexterity
- Highly precise motion scaling
- True 3-D stereo vision
- Tremor filtration
What Surgical Specialist Have Used the Robot?

The da Vinci robotic system has been used by various surgical specialists in many disciplines. Greatest use so far has been reported by general surgeons, pediatric surgeons, cardiovascular surgeons, urologists, gynecologists, endocrine surgeons and surgical oncologists. One of the great advantages of the robotic instruments is that they can be used by different specialists for various types of operations. It allows for broad multi-specialty use. The robot itself is transportable and easily moved to different specialty operating rooms. It does not interfere with the bypass pump used in cardiac surgery, and the system is fully compatible with existing computerized operating rooms at most hospitals.

What are Some Examples of Procedures Performed with the Robot?

The following is a list of operations that can be performed successfully with the da Vinci robotic system:

<table>
<thead>
<tr>
<th>General surgery and pediatric surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrenalectomy</td>
</tr>
<tr>
<td>ACE procedure</td>
</tr>
<tr>
<td>Biliary Pancreatic Diversion</td>
</tr>
<tr>
<td>Cholecystectomy</td>
</tr>
<tr>
<td>Colectomy</td>
</tr>
<tr>
<td>Diagnostic Laparoscopy</td>
</tr>
<tr>
<td>Duodenal/intestinal tumor resection</td>
</tr>
<tr>
<td>Drainage of Pancreatic cyst</td>
</tr>
<tr>
<td>Esophageal-Atresia repair</td>
</tr>
<tr>
<td>Esophageal resection</td>
</tr>
<tr>
<td>Gastrectomy</td>
</tr>
<tr>
<td>Gastric Bypass</td>
</tr>
<tr>
<td>Heller Myotomy</td>
</tr>
<tr>
<td>Hepaticojejunostomy (Kasai procedure)</td>
</tr>
</tbody>
</table>

- Adrenalectomy
- ACE procedure
- Biliary Pancreatic Diversion
- Cholecystectomy
- Colectomy
- Diagnostic Laparoscopy
- Duodenal/intestinal tumor resection
- Drainage of Pancreatic cyst
- Esophageal-Atresia repair
- Esophageal resection
- Gastrectomy
- Gastric Bypass
- Heller Myotomy
- Hepaticojejunostomy (Kasai procedure)
Cardiovascular surgery

- Arrested Heart TECAB
- Atrial Septal Defect Repair
- Beating Heart TECAB
- Esophagectomy
- IMA Takedown (Single and Double)
- Lung Biopsy
- Lung Wedge Resection
- Mediastinal Mass Removal
- Mitral Valve Repair
- Pacemaker Electrode Placement
- Pericardial Window
- Pulmonary Lobectomy
- Sympathectomy
- Tricuspid Valve Repair
- Vascular Anastomosis

The application of this technology to cardiac surgery has the greatest potential impact in patient outcomes, particularly if the use of cardiopulmonary bypass can be eliminated.

Urology and GYN surgery

- Abdominal Torsion Resection
- Adenectomy
- Bladder augmentation
- Donor Nephrectomy
- Hymenectomy
- Laparoscopic Radical Lymphnode resection
- Nephrectomy
- Orchidectomy
- Oophorectomy
- Orchiopexy
- Pyeloplasty
- Resection of Urachal anomaly
- Staging Procedures
- Urotero-uterostomy
- Varicocele repair

The robotic system has allowed urologists to perform very delicate anastomosis of the ureter with safety and precision almost superior to the technique used in open surgery.1

Note: Almost any operation done open can be done using minimally invasive and robotic techniques. However, not all patients are considered candidates for such approaches and careful pre-operative assessment by an experienced surgeon is mandatory in order to determine patient eligibility.

In summary, no one who looks at the data on minimally invasive pediatric surgery objectively can doubt the benefits to children. There is no greater advancement in the surgical sciences in recent years than that provided by minimal access surgery. The new century should continue to witness exciting advances that will improve our ability to provide surgical care to the unborn fetus, infants, children and patients of all ages.


How Do I Refer My Patients to MUSC Children’s Hospital Pediatric Surgery?

It’s easy – just call the Pediatric Surgery office at 843.792.2851 or 1.800.922.5250. Our staff will be available to answer any questions and schedule an appointment on your behalf. If you prefer e-mail, drop Debby a note at lassitde@musc.edu, and she will have your patient set up with an appointment or direct your e-mail/question to the appropriate person.

Our Pediatric Surgeons

- Andre Helbra
- Charles D. Smith
- Cheri Steck
- Robert Cina
- JRB Otherson

Our Staff

- Patty Randinelli, RN, BSN
- Jill Evans, RN, MN
- Lisa Robarge, PA-C, MPAS
- Julie Mansfield, PA-C

- Karly H. Chossen, PharmD, FCPE, BCPS, BCNSP
- Professor of Clinical Pharmacy and Outcome Sciences
- Pediatric Clinical Pharmacy Specialist, Pediatrics/Pediatric Surgery
- 21 years experience in pediatric surgery/nutrition

- Debby Lassiter
- Elaine Cullars

- This manuscript was written with the assistance of Dr. Andre Helbra, Chief of the Division of Pediatric Surgery at the Medical University of South Carolina.

Urology and GYN surgery

- Abdominal Torsion Resection
- Adenectomy
- Bladder augmentation
- Donor Nephrectomy
- Hymenectomy
- Laparoscopic Radical Lymphnode resection
- Nephrectomy
- Orchidectomy
- Oophorectomy
- Orchiopexy
- Pyeloplasty
- Resection of Urachal anomaly
- Staging Procedures
- Urotero-uterostomy
- Varicocele repair

The robotic system has allowed urologists to perform very delicate anastomosis of the ureter with safety and precision almost superior to the technique used in open surgery.1

Note: Almost any operation done open can be done using minimally invasive and robotic techniques. However, not all patients are considered candidates for such approaches and careful pre-operative assessment by an experienced surgeon is mandatory in order to determine patient eligibility.

In summary, no one who looks at the data on minimally invasive pediatric surgery objectively can doubt the benefits to children. There is no greater advancement in the surgical sciences in recent years than that provided by minimal access surgery. The new century should continue to witness exciting advances that will improve our ability to provide surgical care to the unborn fetus, infants, children and patients of all ages.


How Do I Refer My Patients to MUSC Children’s Hospital Pediatric Surgery?

It’s easy – just call the Pediatric Surgery office at 843.792.2851 or 1.800.922.5250. Our staff will be available to answer any questions and schedule an appointment on your behalf. If you prefer e-mail, drop Debby a note at lassitde@musc.edu, and she will have your patient set up with an appointment or direct your e-mail/question to the appropriate person.

Our Pediatric Surgeons

- Andre Helbra
- Charles D. Smith
- Cheri Steck
- Robert Cina
- JRB Otherson

Our Staff

- Patty Randinelli, RN, BSN
- Jill Evans, RN, MN
- Lisa Robarge, PA-C, MPAS
- Julie Mansfield, PA-C

- Karly H. Chossen, PharmD, FCPE, BCPS, BCNSP
- Professor of Clinical Pharmacy and Outcome Sciences
- Pediatric Clinical Pharmacy Specialist, Pediatrics/Pediatric Surgery
- 21 years experience in pediatric surgery/nutrition

- Debby Lassiter
- Elaine Cullars

- This manuscript was written with the assistance of Dr. Andre Helbra, Chief of the Division of Pediatric Surgery at the Medical University of South Carolina.